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INSTALLATION RESTORATION

AT

ROCKY MOUNTAIN ARSENAL

SELECTION OF A CONTAMINATION CONTROL STRATEGY FOR RMA

VOLUME I

FINAL REPORT

ROCKY MOUNTAIN ARSENAL

CONTAMINATION CONTROL PROGRAM

MANAGEMENT TEAM

SEPTEMBER 1983

1806

PREPARED FOR

US ARMY

TOXIC AND HAZARDOUS MATERIALS AGENCY

AND ROCKY MOUNTAIN ARSENAL

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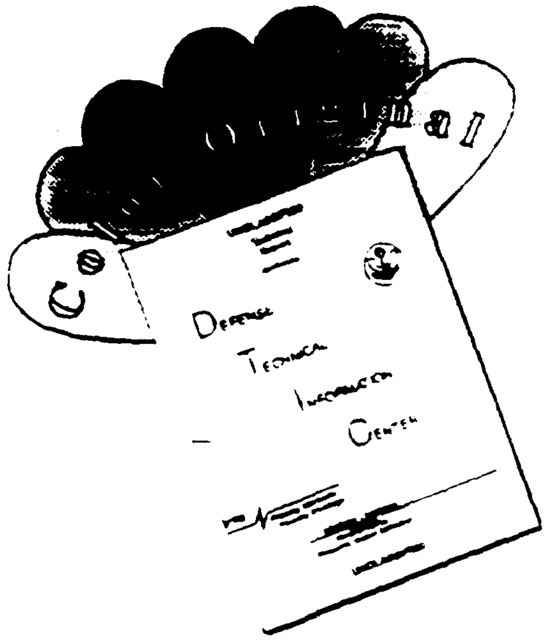

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THIS REPORT DOCUMENTS THE RESULTS OF A TWO AND ONE-HALF YEAR STUDY OF POTENTIAL CONTAMINATION CONTROL STRATEGIES FOR RMA TO ENSURE COMPLIANCE WITH STATE AND FEDERAL STATUTES PERTAINING TO THE RELEASE OF POLLUTANTS TO THE ENVIRONMENT. THE REPORT DEALS WITH AN EXTENSIVE TECHNICAL REVIEW AND ANALYSIS OF MIGRATORY PATHWAYS OF HAZARDOUS CONTAMINANTS AND THEIR SOURCES, AN ASSESSMENT OF APPLICABLE ENVIRONMENTAL LAWS, DEVELOPMENT OF CORRECTIVE STRATEGIES WITHIN AVAILABLE TECHNOLOGY, SCREENING AND EVALUATION OF ALTERNATIVE STRATEGIES AND SELECTION OF A PREFERREDSTRATEGY. THIS DOCUMENT CONSISTS OF TWO VOLUMES AND EXCUTIVE SUMMARY.

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DEPARTMENT OF THE ARMY
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COMMERCE CITY, COLORADO 80022

REPLY TO ATTENTION OF

SMCRM-TO 29 Sep 83

SUBJECT: Selection of a Contamination Control Strategy for Rocky Mountain Arsenal (RMA) - Final Report

SEE DISTRIBUTION

1. Attached herein is the Army final report entitled, "Selection of a Contamination Control Strategy for Rocky Mountain Arsenal (RMA)", furnished under the terms of the Memorandum of Agreement (MOA) signed 6 Dec 82 by the representatives of the Army, Shell Oil Company, the Colorado Department of Health, and the US Environmental Protection Agency, Region VIII.

2. The Army has reviewed all comments received on the draft final report and has included a response to each in Appendix G of Volume II. Where judged appropriate, changes were also made to the text as noted in the responses.

3. Additional review of the Basin A "neck" system has been made and the Army will initiate construction programming for this containment system. Likewise, a review of suggested action on the former deep injection well indicates that even though this site is not considered a migrating source, it is in the best interest of the public and environment to permanently seal this site.

4. The Army feels it has achieved compliance within the terms of the MOA in developing response action for the chemical hazards on RMA. This report is considered part of the Comprehensive Response Plan (CRP) being developed by the Army under Section II of the MOA.

5. The actions proposed in this report will provide containment, control, and selective cleanup of contamination sources existing on RMA. If the guidance on retention of the Arsenal changes, or if environmental laws and regulations change, the Army will reassess the remedial action program. Similarly, if technology improvements should reduce the cost of cleanup or removal actions below continued containment, the Army would review and consider revision of the remedial action program.

1 Attachment
as stated

Richard W. Smith
RICHARD W. SMITH
LTC, CmlC
Commanding

SMCRM-TO 29 Sep 83

SUBJECT: Selection of a Contamination Control Strategy for Rocky Mountain Arsenal (RMA) - Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the results of a two and one-half year study of potential contamination control strategies for Rocky Mountain Arsenal (RMA) to ensure compliance with State and Federal statutes pertaining to the release of pollutants to the environment. The report deals with an extensive technical review and analysis of migratory pathways of hazardous contaminants and their sources, an assessment of applicable environmental laws, development of corrective strategies within available technology, screening and evaluation of alternative strategies and selection of a preferred strategy.

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SELECTION OF A CONTAMINATION CONTROL STRATEGY FOR RMA

FINAL REPORT

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PREFACE

This final report represents the technical evaluations and findings of the Rocky Mountain Arsenal Contamination Control Program Management Team and was prepared for presentation to the Rocky Mountain Arsenal-Installation Restoration (RMA-IR) Configuration Control Board and Commanders, Rocky Mountain Arsenal (RMA) and U.S Army Toxic and Hazardous Materials Agency (USATHAMA).

The report was authorized and funded by the US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland and was prepared under the direction of Mr. Donald Campbell, Senior Project Engineer, and Dr. Michael E. Witt, Associate Senior Project Engineer.

The report is a continuation of the development of Phase II Contamination Control strategies for RMA completed in April 1981, and incorporates the efforts of a multidisciplinary team of government and indust.y specialists, in the complex field of hazardous waste management.

Special acknowledgement is extended to the contributing authors and individuals who provided direct support, advice, technical assistance and comment.

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EXECUTIVE SUMMARY

Rocky Mountain Arsenal (RMA) is an Army installation, 27 square miles in area, located northeast of the city of Denver, and adjacent to Stapleton Airport (Fig. 1). It is surrounded by residential, business, and agricultural real estate. Since 1942, RMA has been used by both government and industry as a site for the manufacture, testing and packaging of various chemical agents and commercial chemicals. Several areas of the property have become contaminated with organic and inorganic chemical wastes as a result of these activities. In 1974, chemicals directly associated with RMA activities were found in groundwater north of the Arsenal. The Army thereupon established the Contamination Control (CC) Program at RMA to identify and quantify the various types of contamination migrating across the boundaries, determine contamination sources, and develop and implement appropriate measures to assure compliance with Federal and State environmental laws.

The Army equipped an analytical laboratory and assembled a team of geologists, hydrologists, engineers and technicians at RMA to develop the critical data needed to address the contamination problem. As a result of the efforts of the CC Program, the Army has identified the sources of contamination, pathways by which contaminants are introduced into the environment and the magnitude of contaminant concentrations. Two groundwater treatment systems, the North Boundary System, and the Irondale System, have been

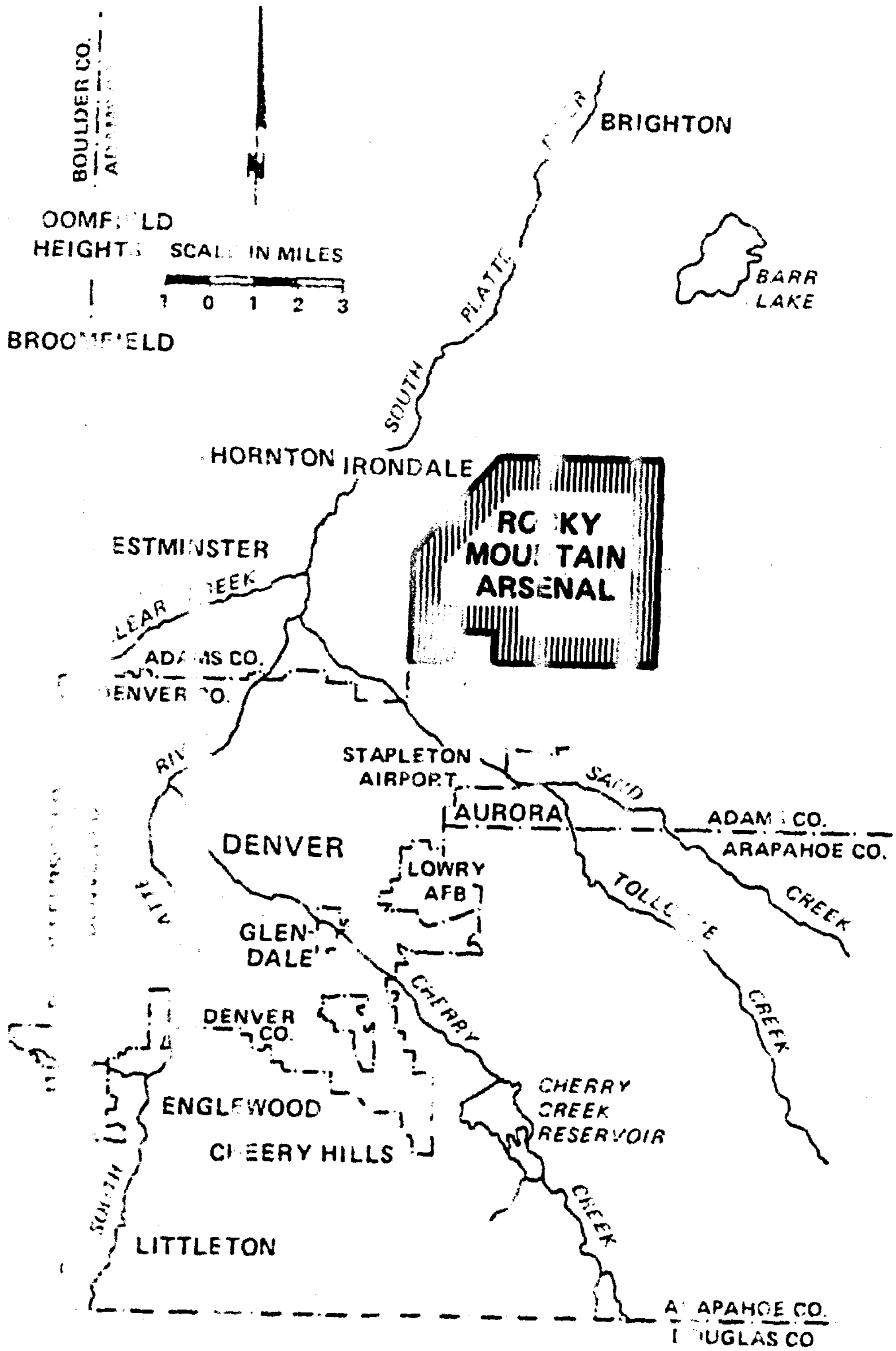

FIGURE 1
MAP OF RMA
DENVER VICINITY

installed at the boundaries to eliminate any immediate threat to the surrounding communities. The North Boundary System was installed and subsequently expanded by the Army; the Irondale system was built by the Shell Chemical Company. Both systems are operational and are successfully intercepting, treating, and replacing the groundwater at these locations. With the installation of the Northwest Boundary Treatment System scheduled for 1983, all contaminated groundwater approaching RMA boundaries will be contained, treated, and reinjected into the surface aquifer.

In addition to those immediate actions required to eliminate potential health risks to the surrounding community, this Selection of a Contamination Control Strategy for RMA study was initiated to determine the most cost- and environmentally-effective alternatives that would bring RMA into compliance with Federal and State environmental laws concerning release of contamination to the environment. Phases I and II of this study developed a statement of work, collated previous reports, assessed compliance and developed and ranked alternatives for control of contaminants. These studies were completed April 1981. The Commander, U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), in conjunction with the Commander, Rocky Mountain Arsenal (RMA), established a joint member Configuration Control Board (CCB) in April 1981. A team of two Senior Project Engineers (SPE), one from each of the two organizations, was tasked with updating the Phase II compliance assessment, evaluation of alternatives developed in Phases I and II of this Selection of a Contamination Control Strategy for RMA study, and selection of a final control strategy, which constitutes Phase III of the study.

A series of constraints were developed by the CCB as guidance to the SPE for this final phase of the Source Control study. These constraints are as follows:

- The strategies developed will reduce contamination at RMA to acceptable regulatory levels.
- The strategies will be implementable by FY88.
- Release of contaminants with the potential for migration from ongoing operations will be evaluated as part of this study.
- The study will not address release of RMA lands or facilities or alternate land use.
- Environmental impacts will be considered.
- Strategy selection will not be influenced by any future apportionment of costs among waste generators.

In addition to these constraints, the following assumptions were made by the SPE:

- The Lower Lakes will be maintained for purposes of flood control and fire suppression.

- Land use surrounding RMA will not change through the study period.
- Systems proposed will address overall conceptual strategies and not specific design elements.
- Any consideration of landfill site requirements will evaluate both on- and off-site options.
- Detailed screening of strategies will utilize criteria consistent with environmental regulations.

A team of representatives from both government and private industry sources was assembled to review the historical data on the environment at RMA, the applicable engineering approaches for corrective action, environmental regulations and geophysical data. This team identified various contamination routes that include the following: wind transport of particles and volatile organics, surface water discharge, biota and groundwater migration. The largest and most significant vector was that of groundwater migration. The areas found to be contamination sources are shown in Figure 2. These areas occupy a small portion of Arsenal land, but through release of contaminants to the groundwater, affect a major portion of RMA.

FIGURE 2
SUMMARY OF RMA
CONTAMINATION SOURCES

In order to effectively manage the movement of contaminated groundwater, the paths by which migration occurs must be identified. Figure 3 depicts the major flows of groundwater through RMA. The relative volumes of groundwater flows are represented by the thickness of the directional arrows. Figure 4 outlines the areas where concentrations of contaminants in groundwater exceed established water quality criteria or standards. The locations at the boundaries where contaminated groundwater is exiting the Arsenal are shown in Figure 4.

The Army and Shell Chemical Company have taken or planned several actions in order to address any immediate response required to protect the health of the public. These actions are labeled "baseline" and comprise a variety of tasks that address contaminant migration at RMA, and include the following:

- Expanded North boundary containment/treatment system
- Northwest boundary containment/treatment system
- Irondale containment/treatment system
- Basin F evaporation
- Contaminated sewer removal
- Sanitary sewer removal/upgrade

NUMBERS ON THIS FIGURE ARE IN FEET ABOVE MSL TAKEN IN 3RD QUARTER 1981

■ BLUE SHADED AREA REPRESENTS AREAS WHERE WATER TABLE IS BELOW THE ALLUVIAL DENVER CONTACT

FIGURE 3
PRIMARY FLOW COMPONENTS AT RMA

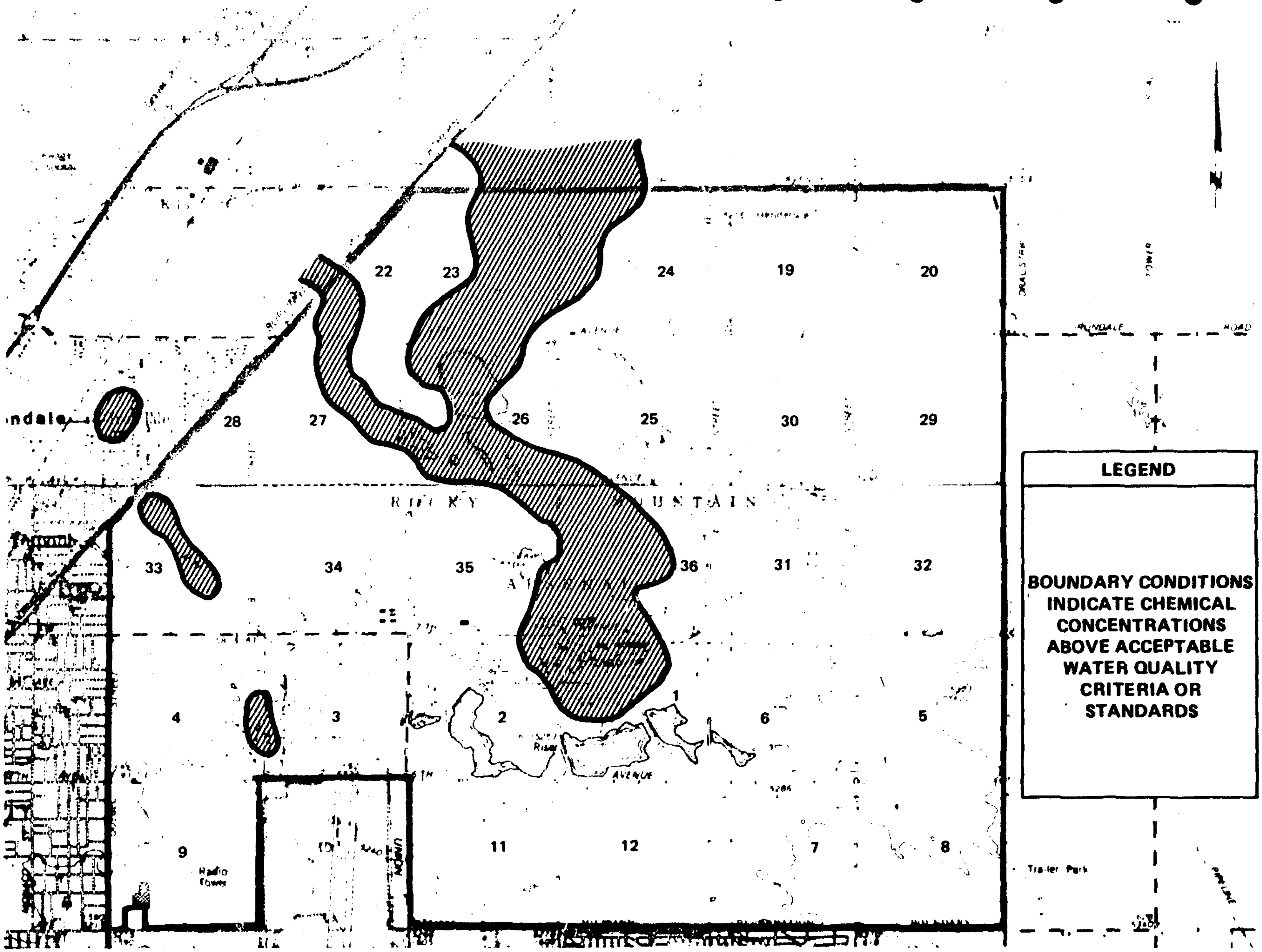

FIGURE 4
CHEMICAL CONTAMINATION PLUME
ABOVE ACCEPTABLE LIMITS

- Basin A windblown dust control
- Lower Lakes sediment removal
- Plugging of deep well
- Secondary source area monitoring

These actions are summarized pictorially in Figure 5, and demonstrate the positive steps that have been initiated or scheduled to protect the environment.

With source areas and migration pathways defined, compliance with Federal and State environmental statutes must be determined. Seven Federal and five State acts apply to the Arsenal; their general and specific applicability to RMA is summarized in Table 1. The Department of the Army, EPA and the State of Colorado are responsible for the enforcement of various portions of these acts. In the evaluation of this legislation, twelve elements were defined as pertinent actions for RMA to achieve regulatory compliance. The elements with which the Arsenal does not comply are listed, along with the source areas, in Table 2.

The three major areas identified require upgrading in order to achieve

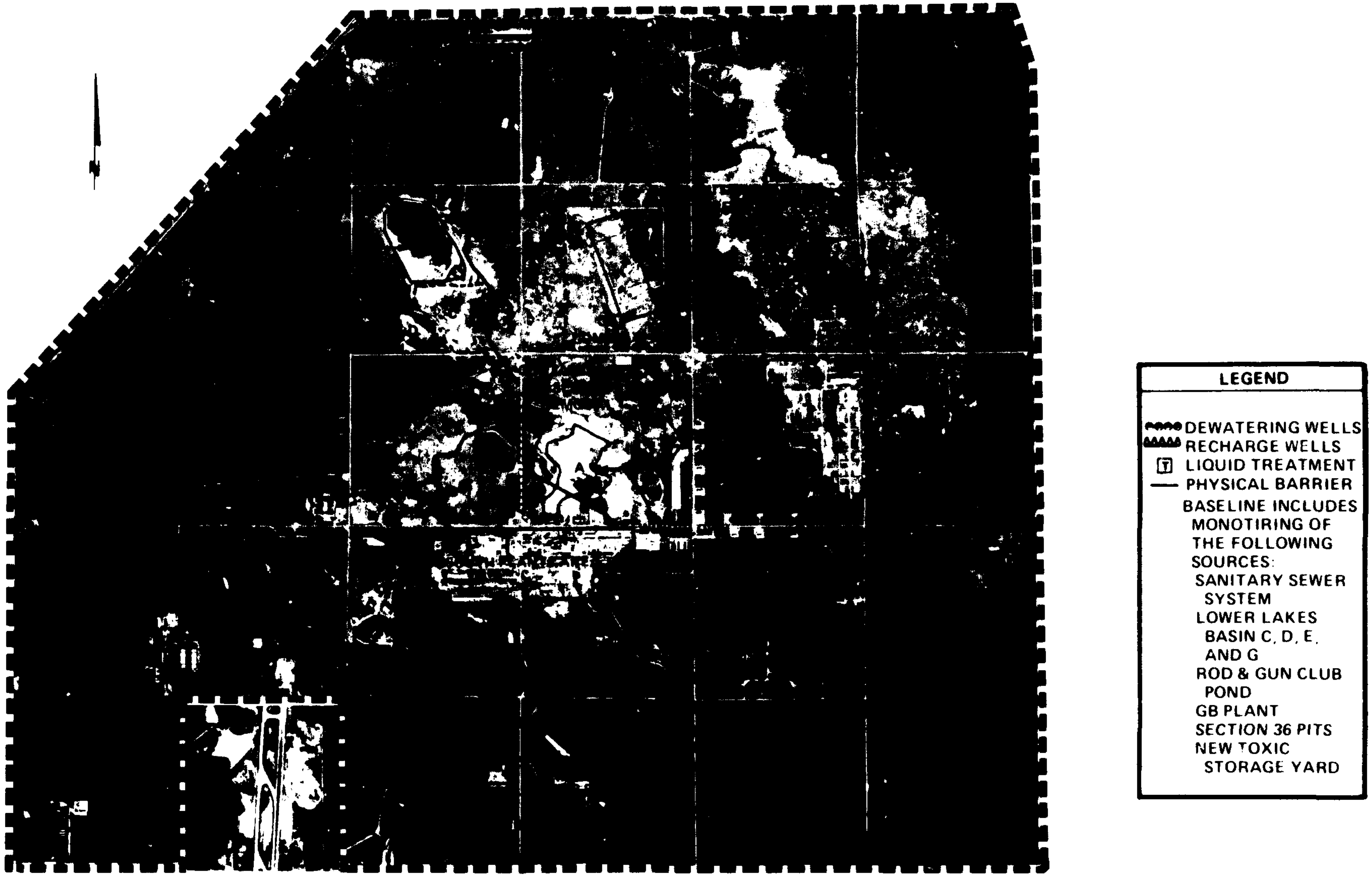

FIGURE 5
BASELINE FOR PHASE III

TABLE 1
SUMMARY OF ACTS APPLICABLE
TO CONTAMINATION CONTROL AT ROCKY MOUNTAIN ARSENAL
(Sheet 1 of 2)

Media	Source	Act	Responsible Regulating Agency	General Applicability	Specific Applicability To RMA*
All	Federal	National Environmental Policy Act (NEPA)	Environmental Protection Agency (EPA) and the Council on Environmental Quality	Directs that environmental impacts will be considered and documented for any decision process.	Governs preparation of EA's and EIS's for contamination control projects on the Arsenal.
Air	Federal	Clean Air Act	EPA Region VIII	Applies National Ambient Air Quality Standards and National Emmission Standards for Hazardous Air Pollutants to point sources.	Not directly applicable since the State of Colorado has received primacy
	State	Colorado Air Quality Control Act	Colorado Department of Health	State version of above Act.	May apply to volatile emissions from Basin F
Water	Federal	Clean Water Act	EPA Region VIII	Applies to point discharges of pollutants to navigable waters. Sets forth suggested water quality criteria.	Applies to NPDES permits for Arsenal
	Federal	Safe Drinking Water Act	EPA Region VIII	Applies to Public Water Systems providing piped water to the public. Sets forth primary and secondary drinking water criteria.	Not directly applicable since the State of Colorado has received primacy
	State	Colorado Water Quality Control Act	Colorado Department of Health	State version of Federal Clean Water Act. Applies primarily to point discharges of pollutants into State waters. State waters are defined as all waters contained in, flowing in or flowing through Colorado. The Act generally endorses the water criteria set forth by the Federal Acts.	This Act was the basis of Colorado issuing three administrative orders against the Army and Shell. Its application to non-point sources such as the inactive waste basins on RMA is unclear
	State	Colorado Safe Drinking Water Act	Colorado Department of Health	State version of the Federal Safe Drinking Water Act.	Would apply if the Arsenal undertook to supply drinking water to the public.

* See Appendix D for a more detailed assessment of applicability to RMA.

TABLE 1
SUMMARY OF ACTS APPLICABLE
TO CONTAMINATION CONTROL AT ROCKY MOUNTAIN ARSENAL
(Sheet 2 of 2)

Media	Source	Act	Responsible Regulating Agency	General Applicability	Specific Applicability To RMA
Control of Hazardous Sub-stances Into All Media	Federal	Resource Conservation and Recovery Act (RCRA)	EPA Region VIII	Sets forth policies and procedures for the handling, transportation and disposal of hazardous wastes from ongoing operations since November 1980.	Governs the closure of Basin F.
	Federal	Comprehen-sive Envrionmental Response, Compensation, and Liability Act (CERCLA)	Department of the Army	Provides for liability, compensation, cleanup and emergency response for hazardous substances released into the environment. Also controls the cleanup of inactive waste disposal sites	This Act applies to all of the inactive waste disposal sites on RMA. The National Contingency Plan provides guidance on the nature and extent of response actions. Army actions are required to be consistent with the NCP.
	State	Colorado Hazardous Waste Act	Colorado Department of Health	Establish siting rules for hazardous waste disposal sites and designate the Department of Health as the responsible agency for hazardous waste management in the State of Colorado.	This Act would require the Arsenal to obtain a Certificate of Designation and a Federal or State issued hazardous waste permit prior to operating a hazardous waste disposal site.
	State	Colorado Solid Waste Act	Colorado Department of Health	Establishes permitting procedures for solid waste disposal sites.	This Act would require the Arsenal to obtain a Certificate of Designation before operating a solid waste disposal site.
Wildlife	Federal	Migratory Bird Treaty Act of 1918	U.S. Depart-ment of Wildlife and Colorado Department	Precludes hunting or killing of select migrating birds except as permitted during open hunting seasons by licenced individuals	Applies to select migratory birds being killed by contact with contaiminated liquids in Basin F.

TABLE 2
SOURCE AREA COMPLIANCE STATUS FOR RMA*

Source Area	Compliance Elements		
	Closure of Basin F	Elimination of Migratory Wildlife Contact with Contaminated Liquids and Sediments	Initiation of Response Actions for Each Primary Inactive Waste Disposal Site
Basin A/South Plants			X
Basin F	X	X	
Rail Classification Yard			X

*Assumes implementation of Baseline Actions

"X" indicates the source areas not in compliance

regulatory compliance. Basin F must be closed under the Resource Conservation and Recovery Act (RCRA) and The Colorado Hazardous Waste Act by either in-situ closure or excavation to an approved landfill. The Basin A and South Plants area, as well as the Rail Classification Yard, are considered primary inactive waste sites, and as such require remedial action to minimize their impact on the environment.

Because of the complexity of these areas and the number of possible alternatives potentially available to address the problems, a detailed assessment of the options and technologies was made. A seven step methodology for development of strategy components was utilized. Under this methodology, options of containment, treatment, storage, disposal and monitoring were considered, with both general and specific technologies being evaluated. From this rigorous assessment, ten separate actions were identified as being feasible for bringing the Basin A/South Plants and the Rail Classification Yard into regulatory compliance.

The results of this evaluation, combined with the required strategy components for Basin F, were evaluated further on the basis of environmental benefit, technical risk, and cost. Specific consideration under these areas was given to capital, operations and maintenance, replacement and present worth costs; regulatory acceptability and time to implement; availability of proven technology; availability of technical data; system compatability and Army liability.

The actions to be taken in these three major areas are as follows:

Basin A/South Plants	-	install a containment/treatment system in the A "Neck" area to capture and clean groundwater from the Basin A area and allow shutdown of the Northwest Treatment System by 2007.
	-	dewater and treat the groundwater in the South Plants to remove the driving force for continued contamination entering the groundwater.
	-	manage the surface water in the South Plants to eliminate ponding in Basin A and contaminated discharge.
Basin F	-	excavate, solidify, and landfill in an approved site on RMA to isolate the contamination and eliminate further discharge to the environment.
Rail Classification Yard	-	remove the contaminated soil to an approved onsite RMA landfill, thereby eliminating the contamination source, and allowing the shutdown of the Irondale system by 1996.

These actions, combined with the baseline actions, comprise the Source Control strategy for the evaluation, and are summarized in Figure 6. The costs, represented in 1982 dollars, are presented in Table 3, and reflect the most cost-effective way to achieve environmental compliance with existing Federal and State statues.

To implement the components of the overall strategy, each action must be classified as completed/operational, programmed, planned or recommended. The

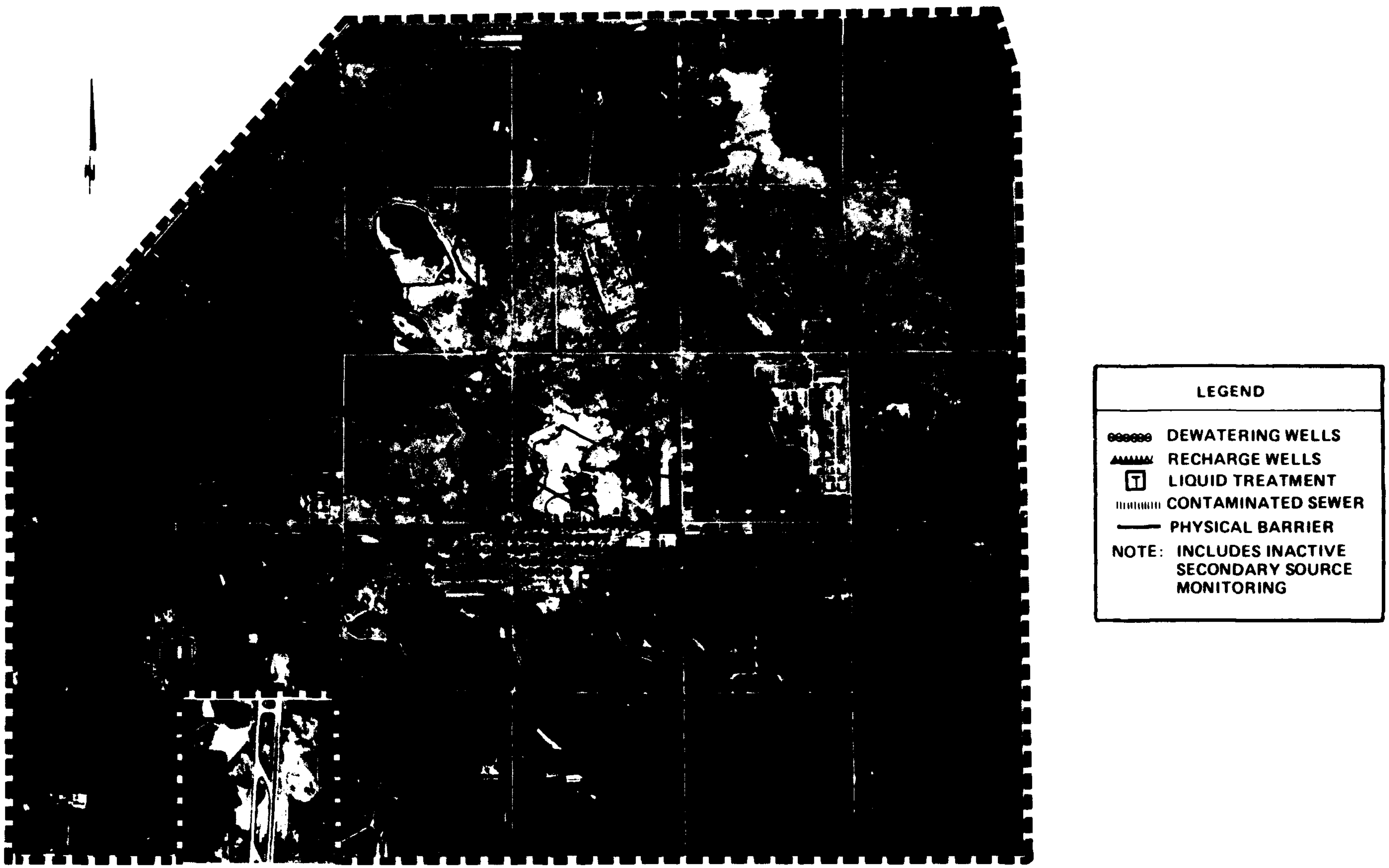

FIGURE 6
SOURCE CONTROL STRATEGY

TABLE 3
COSTS FOR SOURCE CONTROL STRATEGY

System	Capital Cost $M (1982)	Effective O&M Cost $M (1982)	Replacement Cost $M (1982)
1. Baseline			
a. North Boundary: Expanded Containment/Treatment	4.32	11.17	2.28
b. Basin F: Enhanced Evaporation and Contaminated Sewer Removal	1.40	0.54	0
c. Irondale: Containment/ Treatment	1.01	6.23	0.05
d. Northwest Boundary: Containment/Treatment	4.14	10.54	0.18
e. Sanitary Sewer: Removal/ Upgrade	1.43	None	None
f. Basin A Windblown Dust Control	0.17	1.01	None
g. Lower Lakes Sediment Removal	0.86	None	None
h. Plugging of Deep Well	0.30	None	None
i. Inactive Secondary Source Monitoring	None	15.77	None
2. Basin F			
Onsite Landfill	23.64	4.66	None
3. Basin A and South Plants			
a. Neck - Containment/ Treatment	4.27	5.14	1.75
b. South Plants Mound Dewatering	5.62	18.52	4.37
c. Surface Water Management	1.20	3.78	None
4. Rail Classification Yard			
Soil Removal	0.47	-3.68*	None
Total ($M 1982)	48.8	73.7	8.6

*Indicate cost savings due to termination of Irondale System

3A 9 9 83

components falling into the first three classifications are as follows:

Completed/Operational	Programmed	Planned
North Boundary System	Northwest Boundary System	Sanitary Sewer removal/upgrade
Irondale System		Secondary Source Monitoring
Basin F evaporation		Lower Lakes Sediment Removal
Contaminated sewer removal		Plugging of Deep Well
Basin A windblown dust control		

The remainder of the actions require further concept definition in order to submit a design for funding approval. The Contamination Control Program will gather the data required to fill these gaps. Scheduled actions include the following: selection of an optimum landfill site on RMA, pilot testing of the solidification of Basin F liquid, definition of the scope of work for the Lower Lakes dredging, pilot testing of the dewatering and treatment of the South Plants and A "Neck" waters, development of a surface water management

plan for the South Plants, as well as the definition of the extent of the Rail Classification Yard source. In addition to these actions, any requirements for environmental assessments or permits must also be initiated, so that no delays are experienced in design or construction.

It is recommended that the systems listed in Table 3 be continued, if in progress, or initiated in order to bring the Arsenal into full compliance with Federal and State environmental regulations. If the recommendation is approved, the proposed remedies, when complete, will meet the constraints and assumptions as set forth in this study. The remedial actions were selected to realize effective environmental benefits adequately protecting public health, welfare and the environment with the lowest technical risk at the minimum essential cost.

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE OF REPORT

This report documents the results of a two and one-half year study of potential contamination control strategies for Rocky Mountain Arsenal (RMA) to ensure compliance with State and Federal statutes pertaining to the release of pollutants to the environment. The report deals with an extensive technical review and analysis of migratory pathways of hazardous contaminants and their sources, an assessment of applicable environmental laws, development of corrective strategies within available technology, screening and evaluation of alternative strategies and selection of a preferred strategy.

1.2 BACKGROUND

1.2.1 Arsenal Location and History

The RMA occupies over 17,000 acres in Adams County, Colorado (Figure 1-1). The RMA is located approximately 9 to 10 miles northeast of the center of downtown Denver. Denver's Stapleton International Airport extends into the southern border of the RMA. Land use, on land bordering RMA includes agricultural, light industrial manufacturing and residential. Residential population within a radius of 15 miles from the west edge of the RMA totals approximately 1,500,000. This metropolitan area consists of the following Colorado cities: Denver, Aurora, Commerce City, Thornton, Northglenn, Federal Heights, Westminster, Broomfield, Arvada, Lakewood, Littleton, Englewood, Cherry Hills Village, Greenwood Village, Glendale and the heavily populated unincorporated areas of Arapahoe, Jefferson, Boulder and Adams counties.

The property occupied by RMA was purchased by the government in 1942. Throughout World War II, RMA manufactured and assembled chemical intermediate and toxic end-item products, and incendiary munitions.

During the period 1945-1950 the Arsenal distilled available stocks of Levinstein mustard, demilled several million rounds of mustard-filled shells, and test fired 4.2 inch mortar rounds filled with smoke and high explosives. Also, many different types of obsolete World War II ordnance were destroyed by detonation or burning.

In 1947, certain portions of the Arsenal were leased to the Colorado Fuel and Iron Corporation (CF&I) for chemical manufacturing. Julius Hyman and Company assumed the CF&I lease in 1950. CF&I manufactured chorinated benzenes and DDT and Hyman produced several pesticides. Shell Chemical Company (SCC) became a successor to the interests of Julius Hyman and Company in May 1952 and has since leased a portion of the South Plants area for the manufacture of various pesticides and herbicides.

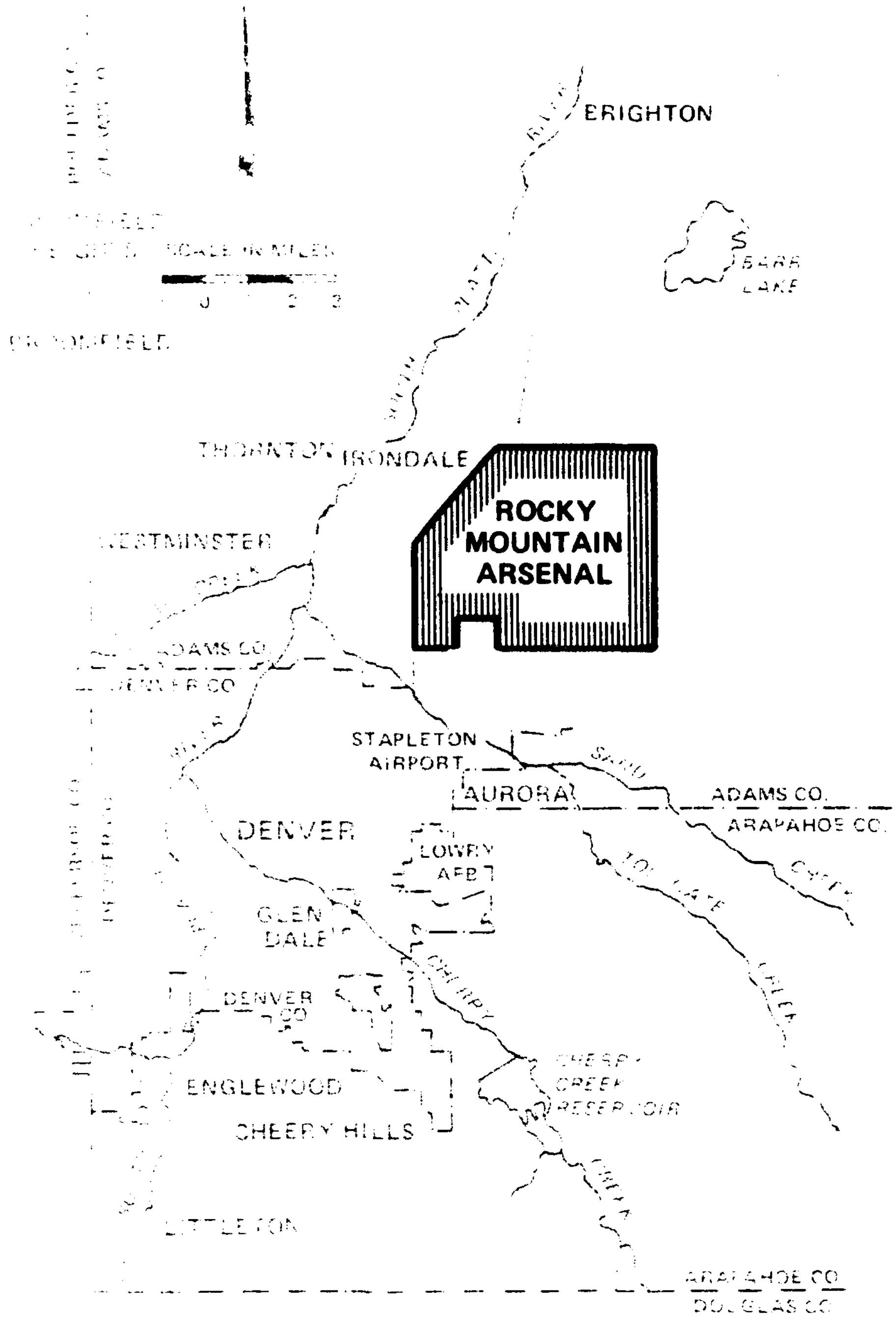


FIGURE 1-1
MAP OF RMA
DENVER VICINITY

Later, RMA was selected as the site for construction of a facility to produce GB agent. This facility was completed in 1953, with the manufacturing operation continuing until 1957, and the munitions filling operations continuing until late 1969.

Since 1970, RMA has been involved primarily with the disposal of chemical warfare material. This disposal included the incineration of anti-crop agent (TX), mustard agent, explosive components, and the destruction of GB agent by caustic neutralization and incineration.

The Arsenal boundary changed configuration during the preceding operations. From 1942 to 1952, RMA covered the area shown in Figure 1-2a. After construction of the GB plant in 1952, the northern boundary was extended one mile northward (Figure 1-2b). About 1964, several sections at the southwest corner were released, leaving the boundary as shown in Figure 1-2c. One more section of the land near the southwest corner was released in 1970 for airport expansion, resulting in the Arsenal boundary that exists today (Figure 1-2d).

1.2.2 Problem Description

There are numerous sites on RMA where hazardous wastes have been intentionally deposited or that have become accidentally contaminated due to past Army and lessee activities. Industrial waste effluents generated at RMA were routinely discharged to unlined evaporation basins. Solid wastes have been buried at various locations throughout the Arsenal. Unintentional spills of raw materials, intermediate and final products have occurred within the manufacturing complexes at RMA. Contaminants from these sites have occasionally entered mobile media (ground water, surface water, air or wildlife) and have been transported off the Arsenal limits. This release constitutes an unacceptable pollution of the environment which must be corrected.

1.2.3 Establishment of The Contamination Control Program

As a result of the discovery of contaminant migration off RMA, the Colorado State Department of Health in 1975 issued three Administrative Orders. The orders, which are described in more detail in Chapter 3 and Appendix D, directed that:

a. the Army and/or Shell Chemical Co. cease any unauthorized (unpermitted) discharge of diisopropylmethyl phosphonate (DIMP) and dicyclopentadiene (DCPD) via an open ditch from Arsenal property;

b. the Army and/or Shell Chemical Co. clean up and control sources of DIMP and DCPD; and

c. the Army and/or Shell Chemical Co. initiate a ground water surveillance program to determine the extent of DIMP and DCPD pollution.

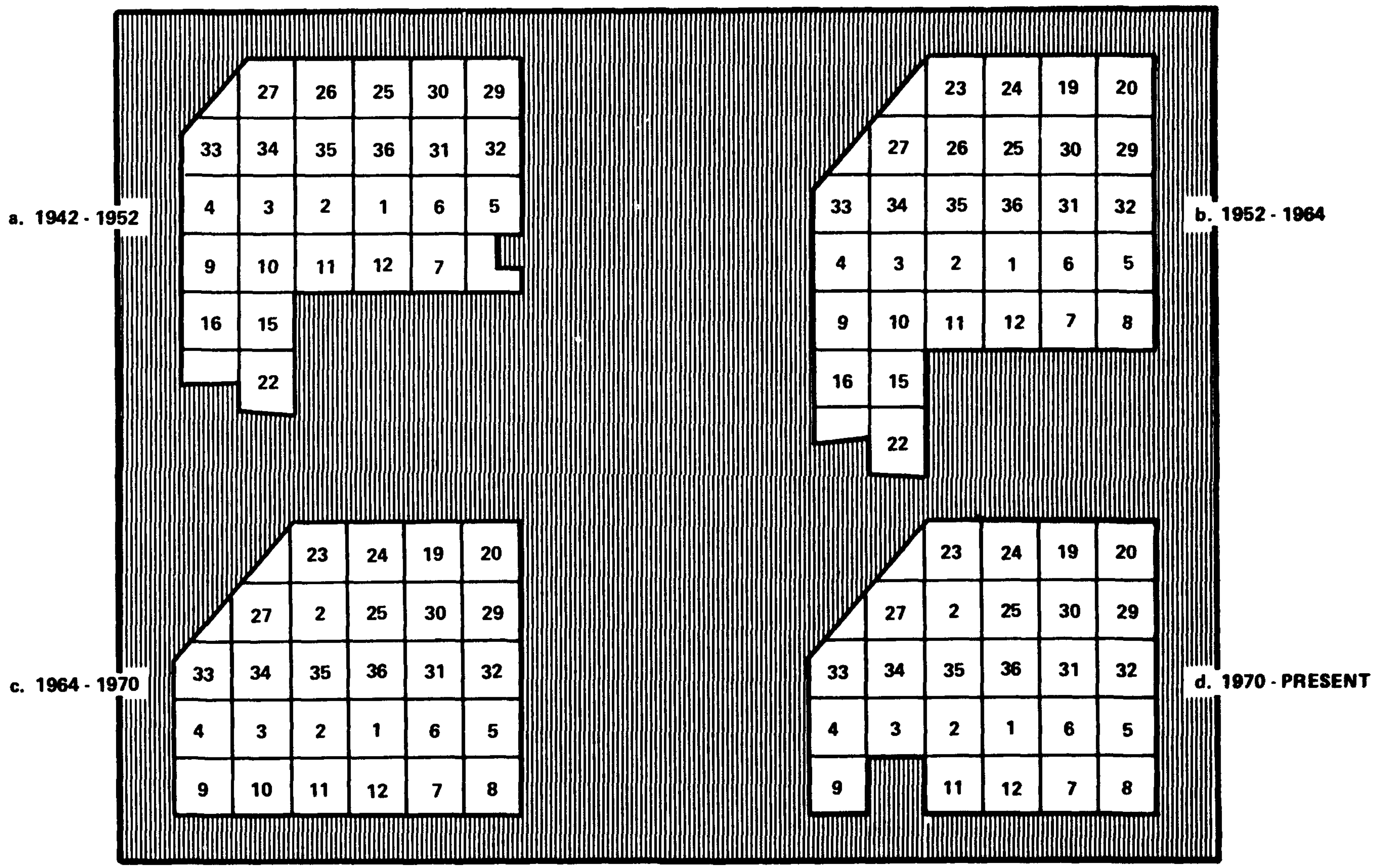


FIGURE 1-2
HISTORY OF BOUNDARY CHANGES FOR ROCKY MOUNTAIN ARSENAL, DENVER, COLORADO.

As a response to these orders, a Contamination Control Program (CCP) was established at RMA by the US Army. The major objective of this program is to ensure that RMA is in compliance with State and Federal environmental laws concerning the release of pollutants to the environment, through the development and implementation of appropriate response measures.

This CC Program is composed of two elements: one funded through the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), the other by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM). These elements encompass problem definition and response actions to assist the Commander of RMA in meeting the program objective stated above.

1.2.3.1 USATHAMA Portion of CCP

The USATHAMA portion, labeled as the Installation Restoration (IR) project, seeks to:

a. Identify existing and potential pollutants resulting from historical operations;

b. Identify the sources of these pollutants;

c. Develop appropriate technology to stop pollutant migration;

d. Recommend and implement interim control actions when necessary;

e. Recommend final control actions to stop release of pollutants; and

f. Assure recommended actions fulfill regulatory requirements.

From this list, it is seen that USATHAMA is, in general, responsible for the identification of contaminant migration from inactive waste disposal sites. USATHAMA is also responsible for the initiation of technical programs leading to the development of any corrective actions to effect protection or cleanup of the Arsenal.

1.2.3.2 AMCCOM Portion of CCP

The AMCCOM portion of the CCP consists of:

a. Development and implementation of interim beneficial actions;

b. Design and construction support of full scale containment/treatment projects;

c. Control systems operation;

d. Continued sampling and analysis of RMA water and wildlife;

e. Surface and ground water management;

f. Data and resource management; and

g. Assurance of regulatory compliance with environmental laws.

These responsibilities demonstrate the continued operations and monitoring actions required to keep the Arsenal in compliance with regulations, once the corrective actions are in place. The actions of data collection and review, development and management of surface water, protection of wildlife, and worker protection are essential in continually reporting corrective actions and compliance to the regulatory agencies. Interim beneficial actions are taken wherever immediate response is necessary and beneficial to ensure Arsenal environmental compliance.

1.3 RMA STATUS WITHIN DEPARTMENT OF DEFENSE (DOD)

The Contamination Control Program goal must be accomplished in a manner compatible with planned future military operations on the Arsenal. RMA is currently scheduled to be retained within the DOD listing of military facilities; therefore, no plans exist to allow the Arsenal buildings and grounds to be released for public use. Current missions include: demilitarization of obsolete chemicals and munitions, the nerve agent mobilization mission, fulfillment of leases to numerous tenants, and long-term operation of contaminant migration control systems. Since RMA is to be retained as a DOD facility, present objectives allow both containment and/or elimination (where applicable) of sources of contaminants. A choice of one over the other can therefore be based principally on environmental effectiveness, technical risk and overall life cycle costs.

1.4 STUDY OBJECTIVE

The objective of this study was to develop and document an overall contamination control strategy, capable of bringing RMA into compliance with applicable Federal and State environmental statutes concerning release of contamination to the environment.

Past control systems placed in operation at the Arsenal have been restricted to limiting contaminant migration at the Arsenal boundaries. To work toward compliance with Federal and State environmental regulations (see Chapter 3), systems for control of contaminants at their respective sources are being evaluated. As

system requirements for source control are different from those for boundary control, other applicable system alternatives than those currently being used at the Arsenal must be identified and assessed.

1.5 STUDY CONSTRAINTS/ASSUMPTIONS

1.5.1 Constraints

The following constraints were placed on the study by the USATHAMA/RMA Configuration Control Board (CCB), which is responsible for providing overall program guidance. These constraints served to place bounds on the study, thus focusing development and selection of alternatives.

a. The strategies developed shall reduce contamination at RMA to acceptable regulatory levels while not substantially altering off-post ground and surface water flows.

b. The strategies shall be capable of implementation by FY88.

c. The strategies shall address migration of contaminants for both historic and ongoing operations. Wastes from ongoing operations which pose no migration threat will not be evaluated as part of this study.

d. The strategies shall not address release of RMA lands or facilities nor consider any alternative land use of the Arsenal.

e. The strategies shall include a preliminary assessment of their environmental impacts as part of this study. Required environmental documentation formalizing a detailed assessment will be prepared once a preferred strategy is selected.

f. The strategies shall not be influenced by any possible future apportionment of project funding that may be made between the Army and its lessees.

1.5.2 Assumptions

To aid in the planning and development of control strategies to meet the goals of the Rocky Mountain Arsenal Installation Restoration, a Contamination Control Program Management Team was established by the USATHAMA/RMA CCB. Heading this team are two Senior Project Engineers (SPE), one from RMA and the other from USATHAMA. These individuals were tasked with developing an approach to achieve a contamination control solution for bringing RMA into compliance with applicable Federal and State environmental laws.

The Senior Project Engineers have established a series of assumptions and study guidance based on the direction given by the Configuration Control Board and technical data from current investigations. These assumptions, which follow, serve as the basis for strategy development and screening throughout the remainder of this report.

a. There must be high potential for regulatory compliance as judged by the regulatory assessment for each strategy recommended for detailed evaluation.

b. The operations of the Lower Lakes will be maintained as part of normal baseline operations (1) to prevent migration of the contaminants in the South Plants Area southward (2) to handle surface flooding and (3) to assist in fire suppression.

c. Present land-use surrounding RMA will remain essentially the same throughout the evaluation period. There will be no consideration of any massive urbanization or residental development, or any increased irrigation well pumping impacting the regional ground and surface water balances or projected trends.

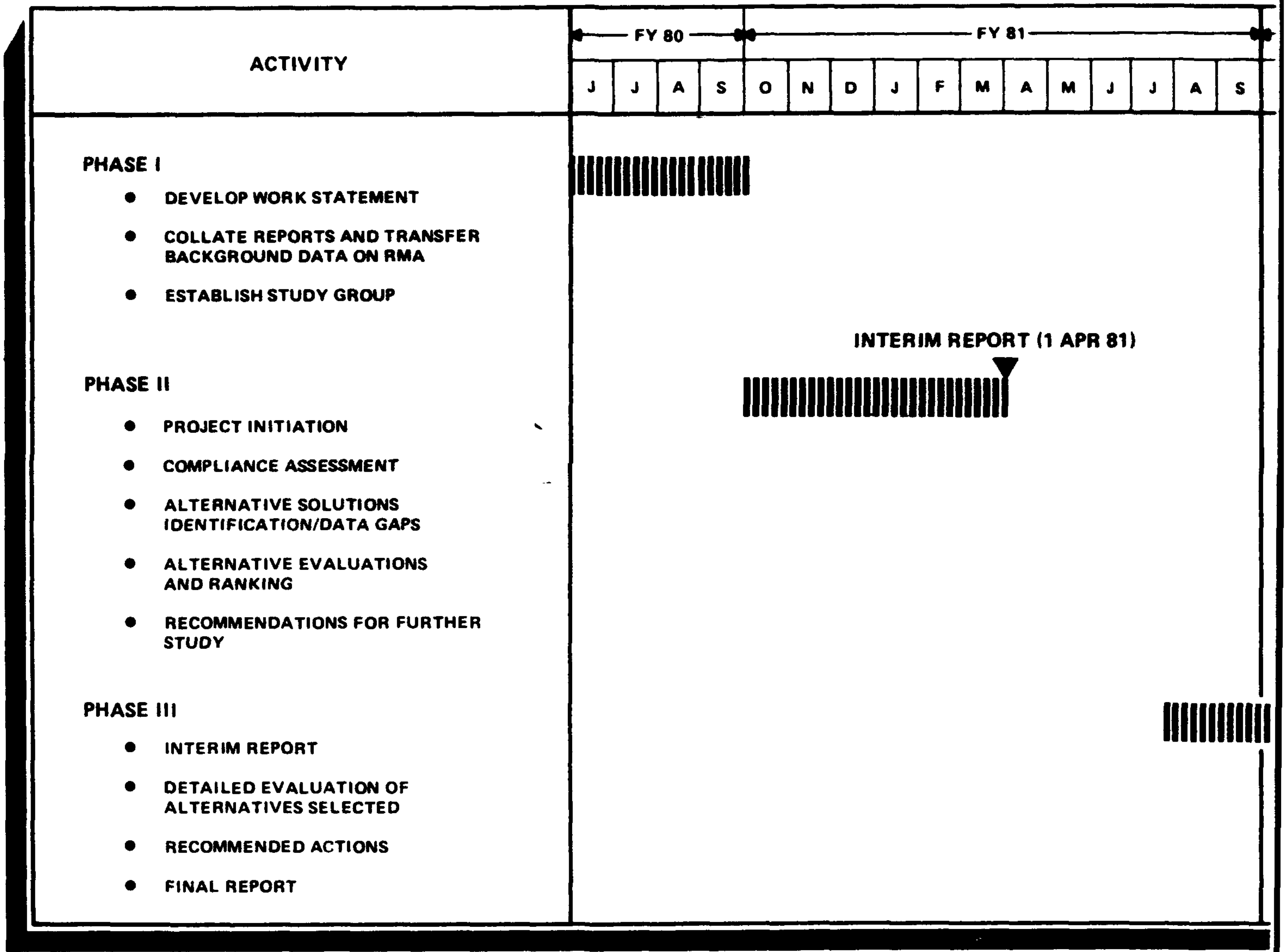
d. The lowest level of strategy definition possible will deal with an overall conceptual approach of contamination control, rather than specific unit operational design elements. Extensive data gaps must be filled before design criteria specifying system sizing, siting and component specifications can be accomplished.

e. Any consideration of hazardous waste disposal will evaluate both on- and off-site landfill options.

f. Detailed screening of strategies will use criteria of cost, benefits and risk, consistent with applicable environmental regulations. The goal of the response action selection is to determine the most cost-effective alternative which minimizes potential adverse impacts on health and the environment.

1.6 STUDY APPROACH

To accomplish the study objective summarized in Section 1.4, a three-phase program approach was initiated in 1980 (Figure 1-3). Phase I was conducted during June - September 1980 and consisted of development of the study work statement, collation and dissemination of background reports and data, and formation of the technical study team. Phase II of the study was conducted from 1 October 1980 to


ACTIVITY
FY 80
FY 81
J J A S O N D J F M A M J J A S
PHASE I
DEVELOP WORK STATEMENT
COLLATE REPORTS AND TRANSFER BACKGROUND DATA ON RMA
ESTABLISH STUDY GROUP
INTERIM REPORT (1 APR 81)
PHASE II
PROJECT INITIATION
COMPLIANCE ASSESSMENT
ALTERNATIVE SOLUTIONS IDENTIFICATION/DATA GAPS
ALTERNATIVE EVALUATIONS AND RANKING
RECOMMENDATIONS FOR FURTHER STUDY
PHASE III
INTERIM REPORT
DETAILED EVALUATION OF ALTERNATIVES SELECTED
RECOMMENDED ACTIONS
FINAL REPORT

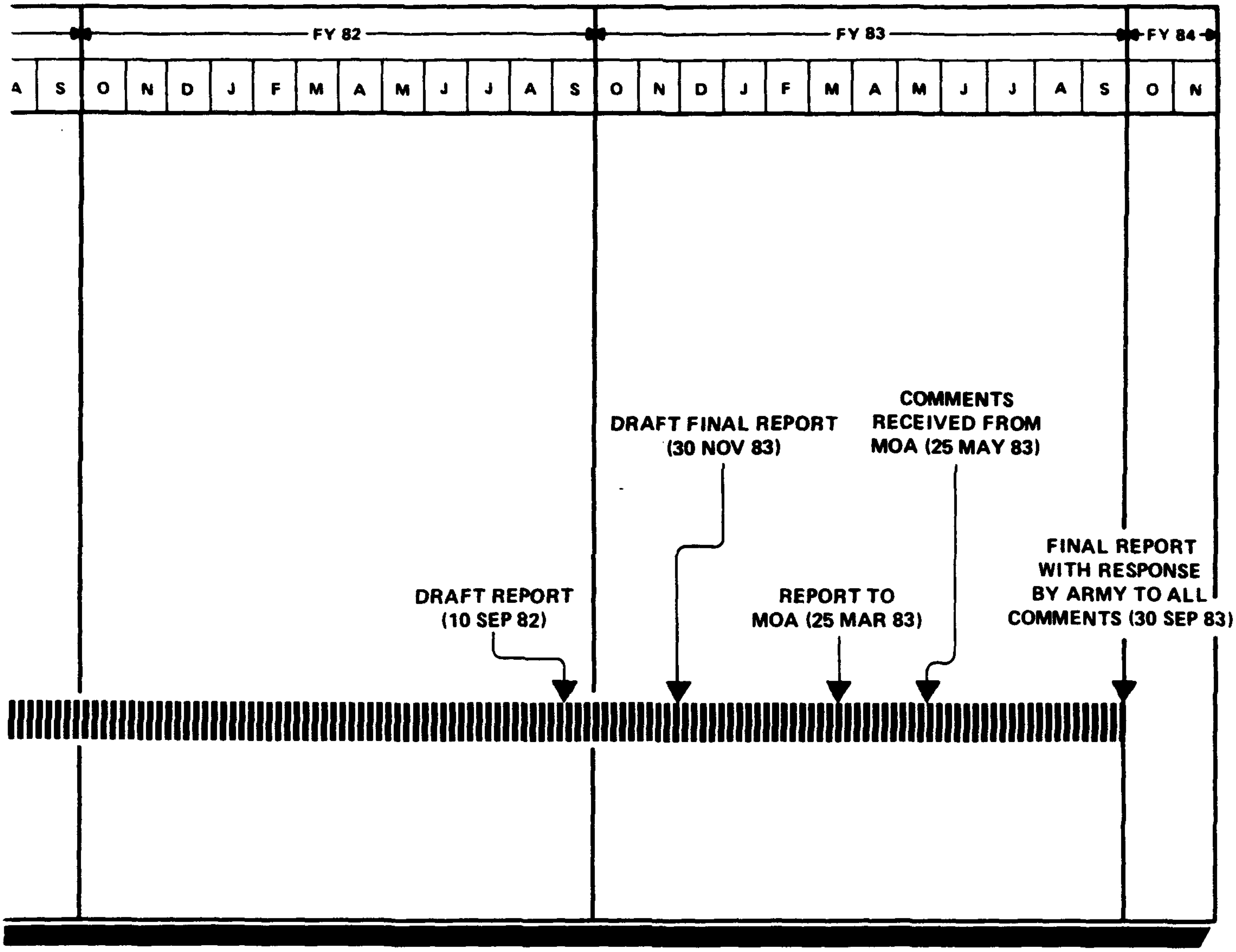


FIGURE 1-3
STUDY SCHEDULE

31 March 1981, resulting in the development of a broad range of alternative contamination control schemes, as detailed in an interim report (1)*. These schemes required further detailed problem definition and technology development efforts prior to selection of a preferred alternative. The final Phase III portion of the study was conducted during 1981-1982, and is completed with the submission of this report.

Cleanup of all contaminated sites on the Arsenal was not addressed throughout the study, since the current cost estimate for decontamination of RMA is cost prohibitive (2). Only in selected cases where it has been found to be either cost effective, required by existing Army policy, or by regulation (e.g., Resource Conservation Recovery Act) has cleanup of the contamination site been evaluated versus containment strategies. Reevaluation of the preferred control strategy will be required if Arsenal release options are established.

Since the contamination control concept is one of containment, rather than cleanup, it is essential that the solution be comprehensive, so that the interrelationships between system components are identified and economy of scale is achieved. The strategy developed must address all contaminant release, with provisions for containing potential sources, if the need arises.

This report, "Selection of a Contamination Control Strategy for RMA," will be used in developing and implementing a long-range Comprehensive Response Plan (CRP) for Rocky Mountain Arsenal.

1.7 REPORT OUTLINE

The approach utilized within the multi-phased source control study for selection of the optimum contamination control strategy at RMA has also been the basis for organization of this report (Figure 1-4). The remainder of Volume I presents results of the study in a summary format. Volume II includes pertinent appendices which provide detailed information, allowing a more thorough understanding of the rationale employed within the study.

*Note: Numbers appearing in elevated parenthesis are keyed to reference numbers in Appendix A.

VOLUME I

Chapter 2:
Technical Background Information

- Overview of Contamination Sites
- Summary of Migration Pathways and Associated Contamination Levels
- Description of Contamination Source Areas

Chapter 3:
Legal Compliance Assessment

- Overview of Legal Requirements
- Assessment of Pertinent Laws
- Definition of Compliance for RMA
- Baseline Control Actions
- Compliance Assessment
- Source Area Compliance Status
- Rod and Gun Club Pond
- Section 36 Pits
- New Toxic Storage Yard
- Northwest Boundary

Chapter 4:
Development of Control Strategy Components

- Categorization of Response Actions
- Strategy Component Selection for Essential Actions at Basin F
- Strategy Component Selection for Discretionary Actions at Basin A/ South Plants and Rail Classification Yard

Chapter 5:
Selection of Optimum Control Strategy Components

- Overview of Selection Methodology
- Strategy Component Selection for Essential Actions at Basin F
- Strategy Component Selection for Discretionary Actions at Basin A/ South Plants
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- Summary of Control Strategy Components

Chapter 6:
Recommended Contamination Control Strategy for RMA

- Strategy Discription
- Requirements for Strategy Implementation

VOLUME II

Appendix A:
References

Appendix B:
Glossary of Terms

Appendix C:
Detailed Assessment of Ground Water Conditions Beneath RMA

Appendix D:
Review of Pertinent Regulations

Appendix E:
Background Cost Data and Present Worth Analysis

Appendix F:
Map of Contamination Sites on RMA

Appendix G:
Responses to Comments on Draft Final Report from CDH, EPA and Shell Chemical Co.

FIGURE 1-4
REPORT OUTLINE FOR THE RMA SOURCE CONTROL STUDY

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CHAPTER 2
TECHNICAL BACKGROUND INFORMATION

2.1 INTRODUCTION

The technical feasibility and rationale for selection of any contamination control strategy component relies heavily upon the environmental setting in which the component is to be placed, and the contamination levels within the environment with which that component must contend. In addition, to define the major source areas and to develop a sound, arsenal-wide corrective action strategy, an understanding of the overall migration pathways that permit release of pollutants to the surrounding environment, and the contaminant distribution within these pathways, is essential. This chapter will summarize these critical data through the evaluation of four environmental media: air, biota, surface water and ground water transport.

Data utilized in this chapter have been generated as a result of many years of investigation at RMA. These efforts have culminated in the publication of over 600 technical reports concerning problem definition and technology development pertaining to the Arsenal. Individual study has occurred at each source area of interest and concentrated on defining the major pathways of containment migration from past usage of hazardous wastes at RMA.

A general site map of the Arsenal is provided in Figure 2-1 to aid in locating the key features of RMA. These features will be referenced throughout the chapter.

2.2 OVERVIEW OF CONTAMINATION SITES

The variety of operations conducted at Rocky Mountain Arsenal since 1942 by the Army and various lessees have resulted in numerous hazardous materials being handled at the Arsenal. Wastes from these operations have typically been deposited on-site. There have also been spills, leaks and other uncontrolled emissions of potentially harmful substances into the environment at RMA. Consequently, contaminants have entered migratory pathways and in some cases have been released from the installation property.

Several record searches (2)(3)(4) have been completed to identify historic comtamination sites on RMA resulting from the storage, disposal, spillage or transport of hazardous materials. Arsenal records and aerial photographs have been reviewed. Personnal interviews and site tours were conducted to identify a complete index

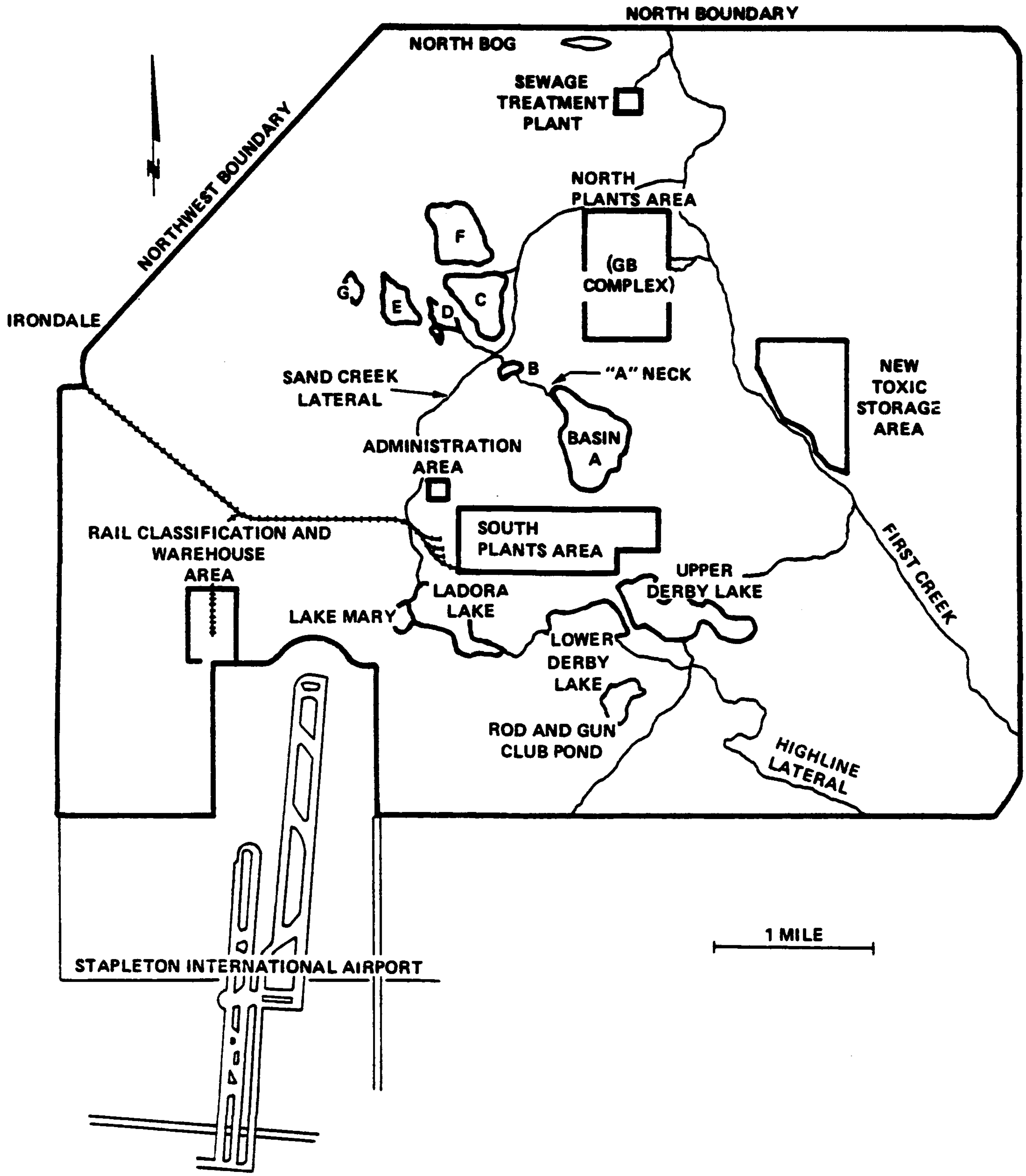


FIGURE 2-1.
GENERAL MAP OF RMA

of areas to be investigated as potential contamination sites. A map locating each of the 165 identified sites is presented in Appendix F.

Review of the composite listing of all 165 sites yielded the following conclusions:

a. The sites do not all represent the same potential for release of contaminants to the environment. Some areas are noted from aerial photography as contamination sites due to the mere presence of activities handling hazardous materials at that location while others are known disposal locations of gross quantities of liquid wastes.

b. The sites are associated with a large cross section of Arsenal operations and thus may consist of liquid wastes, solid wastes, unexploded ordnance, residual nerve agent contamination, etc., or any combination of these.

c. The sites are located throughout RMA with the highest density in the center of the Arsenal, in and around the manufacturing complexes.

2.3 MIGRATION PATHWAYS AND ASSOCIATED CONTAMINATION LEVELS

Release of contamination to the environment and its subsequent migration from the point of release may take many forms. Of particular importance are those pathways that result in an endangerment to public health or welfare, or contribute to ecological stress. The four principal migratory pathways (air, biota, surface water and ground water) have been assessed to identify associated contamination levels thus allowing a determination of which of the 165 contamination sites represent a source area of concern.

2.3.1 Air

The prevailing wind at RMA is from the south, paralleling the foothills west of Denver. Occasional winds are also out of the NNW, N and NNE. Wind speeds average about 9 miles per hour annually. The windy months are March and April, with gusts as high as 65 miles per hour. These months come immediately after the four driest months of the year (November through February). Therefore, March and April have the highest potential for dust storms and movement of wind blown contaminants.

Air quality is influenced by contamination-bearing particulates and volatile emmissions. Areas of concern are the migration of particulates from dry waste basins, and release of volatile organics

from Basin F. These could cause a health hazard downwind of the source if a sufficient mass of a toxic compound were carried by winds moving across RMA.

Because of these concerns, the US Army Environmental Hygiene Agency (AEHA) was requested to examine potential air quality problems and recommend appropriate precautions. A particulate dust study of the dry basins was conducted in 1981 by AEHA to evaluate the health hazard posed by low level contamination effects of fugitive dusts[5]. The contaminants studied were arsenic, mercury, cadmium, copper, lead, aldrin, dieldrin, and endrin. Concentrations of the various contaminants monitored in the fugitive dust did not appear to pose a significant hazard to members of the general population around RMA, or to individuals occupationally exposed to wind blown dust emanating from disposal basins at RMA. An additional study to determine the impact of volatile organic emissions from Basin F was recently completed (19). The data indicate that operation of the enhanced evaporation system at Basin F will not effect the overall lifetime cancer risk to the general population.

2.3.2 Biota

Rocky Mountain Arsenal provides a variety of terrestrial and aquatic habitats that are unique to the Denver area. The importance of these habitats on RMA stems from the facts that (1) the surrounding area is largely developed for commercial, residential, or agricultural uses, and (2) the existing habitats support game species with recreational interest for man.

The diversity and abundance of animal species reflect the plant communities found on the Arsenal. There is a range of mid-successional vegetation weed types (dominated by sand dropseed, needle and thread, and red three-awn) in addition to the "climax" shortgrass prairie type, where blue grama is the dominant. RMA also supports scattered woodland and thicket communities, as well as wetland communities that include lakes, streams, and a bog.

The resident game species that give the Arsenal recreational value include desert cottontail, mule deer, mourning dove, ring-necked pheasant, jack rabbits, whitetail deer, chukers, pike, rainbow trout, black bullhead and largemouth bass.

The 1980 federal listing of endangered and threatened species did not include any of the fish, amphibians or reptiles that reside on RMA[6]. Two listed birds may use the area during migrations. Several bird species, a mammal and possibly two plant species that could occur on or near RMA are considered rare or endangered by state authorities and professional biologists.

In addition to providing a range of habitats not available in the immediate vicinity, another unique characteristic of RMA is the presence of unusually high population densities of hawks and owls.

Biota may serve as a transport mechanism for contaminants. Various plants and animals at RMA contain contaminants associated with past Arsenal activities. The initial Ecological Monitoring Program conducted in 1977 evaluated a number of potential pollutants in a representative cross section of animal and plant life[7]. This study found that dieldrin, DDT and p-chlorophenylmethyl sulfone were present in all species studied and that diisopropylmethylphosphonate (DIMP) was present at high levels in the biota of basin areas, with lower levels noted in the north boundary flora.

Since 1977, monitoring of biota for contaminants has been limited to fish, rabbits and game birds, and to vegetation adjacent to some of the water sampling wells. Monitoring of game animals has demonstrated that, in all species studied, tissue contaminant levels exist above the Food and Drug Administration (FDA) guidelines for commercial food products. Vegetation presents a potential source of contamination to seed eating birds, such as mourning doves and pheasants, and to rabbits. Pheasants and rabbits are confined to relatively small areas and are of concern only around the immediate environs of the Arsenal. Mourning doves and waterfowl could potentially accumulate contaminants from vegetation growing in contaminated soil or where contaminated water is available to the plants. Because contaminant levels exceed FDA guidelines, hunting on the Arsenal has been prohibited, and fishing is restricted to catch-and-release. These actions are intended to mitigate exposure to humans through the consumption of the game.

2.3.3 Surface Water

2.3.3.1 General

The two primary components defining RMA hydrology are precipitation patterns and watershed configuration. The annual precipitation for the Arsenal (recorded at adjoining Denver-Stapleton Airport) during 1977 to 1981 ranged from a low of 10 inches in 1977 to a little over 20 inches in 1979. Most of the yearly precipitation at RMA occurs between March and August. Since the Denver area has a semi-arid climate, evapotranspiration demand is high. This restricts infiltration to areas along regular flow routes and areas which pond during high precipitation events[8]. Most of the flow routes on RMA follow sandy bedded channels with a capacity for high infiltration.

The Arsenal is covered by two major drainage basins; Irondale Gulch and First Creek (Figure 2-2). The watersheds or drainage basins

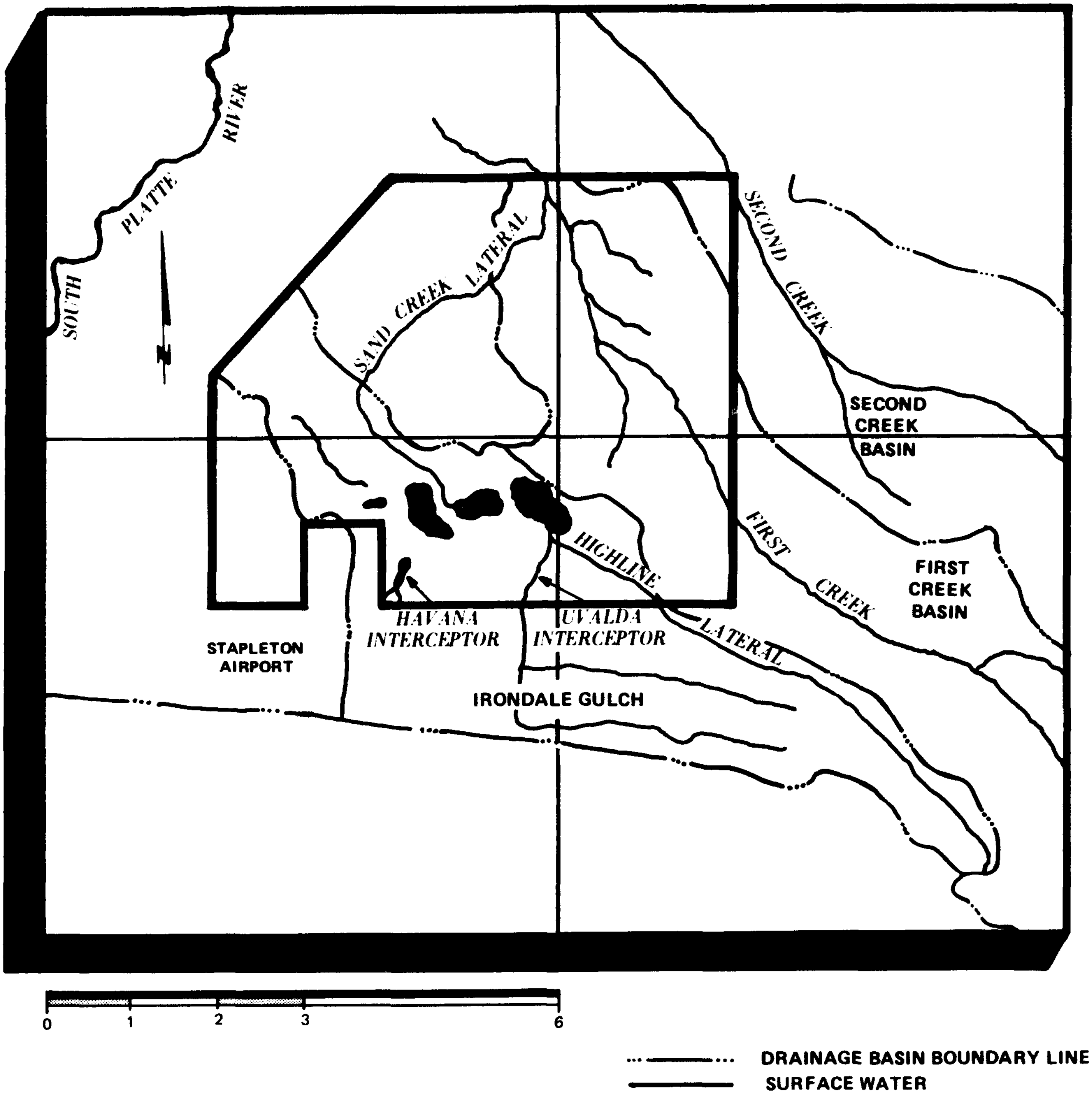


FIGURE 2-2
BOUNDARIES OF MAJOR DRAINAGE
BASINS THAT FLOW
ACROSS THE ROCKY
MOUNTAIN ARSENAL

in the figure depict areas within which all surface water tends to flow to a central line or direction. For example, in the First Creek drainage basin all surface runoff within the boundary would flow towards First Creek and eventually northwest to the South Platte River.

2.3.3.2 Major Flow Routes

The major surface water migratory route in the First Creek watershed is First Creek. The Creek has a well defined channel that crosses the east and north boundaries of the Arsenal. At times it is intermittent with surface water flow ending and reappearing further downstream. During the spring and major storm events, the flow is continuous and has caused some flooding in the history of the Arsenal. Treated effluent from the RMA wastewater treatment plant contributes to flow in the Creek at the north boundary. A marshy bog is ajacent to First Creek as it exits the Arsenal. The bog is in direct contact with the water table and therefore reflects local ground water conditions.

Irondale Gulch has poorly defined channelization because the drainage area is smaller and because drainage patterns have been modified by the construction of subdivisions, the Lower Lakes, man-made channels and storm drains. There are four major flow routes within this drainage basin. The Highline Lateral is a man-made channel which serves as an overflow for creeks in southeastern Denver. Flows are occasional and controlled by man-made structures. Water in the Lateral ultimately reaches Lower Derby Lake. The Uvalda Interceptor collects storm runoff from the residential area south of the Arsenal and transports it to Lower Derby Lake. This is a well defined unlined channel which has been breached during major flood events.

The Lower Lakes consist of four man-made lakes and one pond. Upper Derby Lake is dry and serves as an overflow in case of flood. Lower Derby Lake, which receives the local storm runoff is in direct contact with the water table. This lake serves as a cooling water source for the RMA power station. One million gallons per day is pumped from Lower Derby. Approximately two hundred and fifty thousand gallons per day are lost to evaporation and leaking pipes. The remainder is recharged to the ground water through Lake Ladora which is also in direct contact with the water table. The Derby and Ladora Lakes are both recharge and discharge areas. In other words, during periods of high flow (March through August), ground water is replenished through these lakes. During periods of low surface flows (September through February), ground water is released to surface water through the lakes.

Lake Mary, located west of Ladora, is not in contact with the water table and therefore is primarily a recharge area. The Rod and Gun Club Pond was created during a major flood. This pond is usually dry except during major flood events wnen it receives overflow from the Uvalda Interceptor and Lower Derby Lake.

The final major flow route in the Irondale Gulch watershed is the Havana Interceptor. Storm runoff from the airport and a small industrial complex flows through a concrete conduit and an unlined channel to a small ditch. This ditch usually contains water and acts as a source of recharge to the ground water.

2.3.3.3 Minor Flow Routes

In addition to the above routes, many minor flow paths exist on the Arsenal. Three can be identified as possible migration routes. The Sand Creek Lateral is a man-made conduit which transported fresh lake water to basins in Section 26. This lateral is no longer in use.

An active flow route for storm runoff extends from the South Plants Area to Basin A where the water ponds and eventually evaporates or infiltrates. The North Plants Area also has an active storm drainage outfall which transports flow to First Creek. All of these flow paths are unlined and have a high potential to provide recharge to the ground water system.

2.3.3.4 Contaminant Levels in the Environment

Limited information is available on contamination of surface water bodies. The off-post storm drainage paths (Highline Lateral, Uvalda and Havanna Interceptors) which contribute the major volume of flow are free of Arsenal related contaminants. Preliminary analysis has been performed on First Creek. Pollutants found include diethyl and dibutyl pthalates and cyclohexanone. Since the stream is intermittant, the contaminants infiltrate into the ground water before reaching the northern Arsenal boundary via surface flow except possibly during major flood event.

The Basin A ditch has been found to contain high amounts of various contaminants including chloroform, trichloroethylene, tetrachloroethylene, toluene, xylene, ketones and benzene. Two of the Lower Lakes have been sampled regularly for the past five years. Actual lake water is relatively clean as contaminants are found concentrated in lakebed sediments. Sediment contaminants include dieldrin and mercury.

In summary, of four major surface flows coming onto the Arsenal only First Creek, which is an intermittent stream throughout most of the year, crosses the entire Arsenal. These routes appear to be free of contaminants. The localized minor surface flows, such as the Basin A ditch, have been found to contain pollutants which probably were picked up from past spills on surface soils. These minor flow routes are not continuous and do not cross the Arsenal boundary. Generally, RMA surface water contributes little to the migration of surface contaminants. Any effect on migration is felt principally through the driving head that surface water provides to the ground water table.

2.3.4 Ground water

A summary of the ground water conditions at Rocky Mountain Arsenal, including a description of the aquifers, ground water flow and contamination migration patterns, is given in this Chapter. A more detailed description is given in Appendix C.

2.3.4.1 Water Bearing Formations at Rocky Mountain Arsenal

Geologic conditions at RMA have been explored through extensive test drilling. More than 1,000 test borings and wells have been installed to study subsurface conditions and ground water quality. Most of these wells were installed to explore the shallow aquifer, which consists of clay, silt, sand, and gravel. During the early investigations, the borings were concentrated in central and northern sections of the Arsenal near areas of known contamination or at boundaries. During FY81 these data were integrated, and a regional drilling program was designed to fill the data gaps and to answer many of the questions related to the ground water flow and contamination migration systems.

Regionally, RMA is located within a portion of a structural Denver Basin. This structure contains thousands of feet of sediment. The regional geology and hydrology of these deep sediments as well as the regional ground water flow are described by Robson and Romero 1981 (9).

The two upper aquifers have been affected by past activities on RMA property. The alluvial aquifer, which is closest to the ground surface, consists of a thin deposit of alluvium and windblown deposits. These deposits are 10 to 20 feet thick over most of RMA but reach depths greater that 130 feet in the vicinity of the Irondale Community. The thick accumulations are found in ancient bedrock valleys or channels representing tributaries of the ancient South Platte River drainage system.

The bedrock underlying the alluvium is the Denver Formation. In general, this formation consists of carbonaceous shale and claystone with occasional sandstone and siltstone lenses. It is a typical deltaic deposit with cyclical repetition of silt, clay, and water-bearing sand units. The sands in the Denver are lenticular and occupy sinuous channels that are difficult to trace from boring to boring.

A generalized example of regional ground water movement, in both the vertical and horizontal directions, is shown in Figure 2-3. This hydrogeologic cross section also shows the formations overlying and underlying the Denver Formation (the Dawson and Arapahoe Formations, respectively) and the relationship between the Denver Formation and alluvium beneath RMA. On a regional scale, the figure indicates that RMA is near a major ground water discharge area, the South Platte River. However, on a local scale, areas of both discharge and recharge exist.

2.3.4.2 Description of Ground Water Flow System

An example of the typical hydrogeologic conditions below RMA is shown in Figure 2-4. This vertical section runs from the southeast boundary of the Arsenal, through an area just east of the South Plants, continuing through Basin A, Basin A Neck, east of Basin F to the corner of the north and northwest boundary of RMA. The section shows the lenticular nature of the Denver Formation and the relative variability in permeabilities. The section indicates that there is no uniform permeability contrast between the alluvium and the bedrock; moderate and low permeability zones frequently extend across the alluvium/bedrock contact; and there is interchange of water between the alluvium and bedrock.

The arrows on the section indicate probable direction of ground water flow and indicates the potential for downward percolation of water. However, the section also indicates that if contaminated ground water migrated vertically downward to a Denver sand, the water also has a potential to migrate updip through the Denver Sand and to discharge into the alluvium. For example, as shown on Figure 2-4, near Basin A Neck there is a downward component of flow at the location of Well N3. As water reaches the Denver sand zone, labeled with screen number 4 in Well N3, it has a potential for moving updip in the sand layer towards Well DB4. Continuing along this pathway, the water is discharged back into the alluvium or water-table aquifer near Well DB4.

The complexity of the hydrogeologic system, including the interchange of water between the alluvium and deeper Denver Sands, has been considered when conceptualizing remedial action schemes. A more detailed description of the hydrogeologic conditions at RMA is discussed in Appendix C.

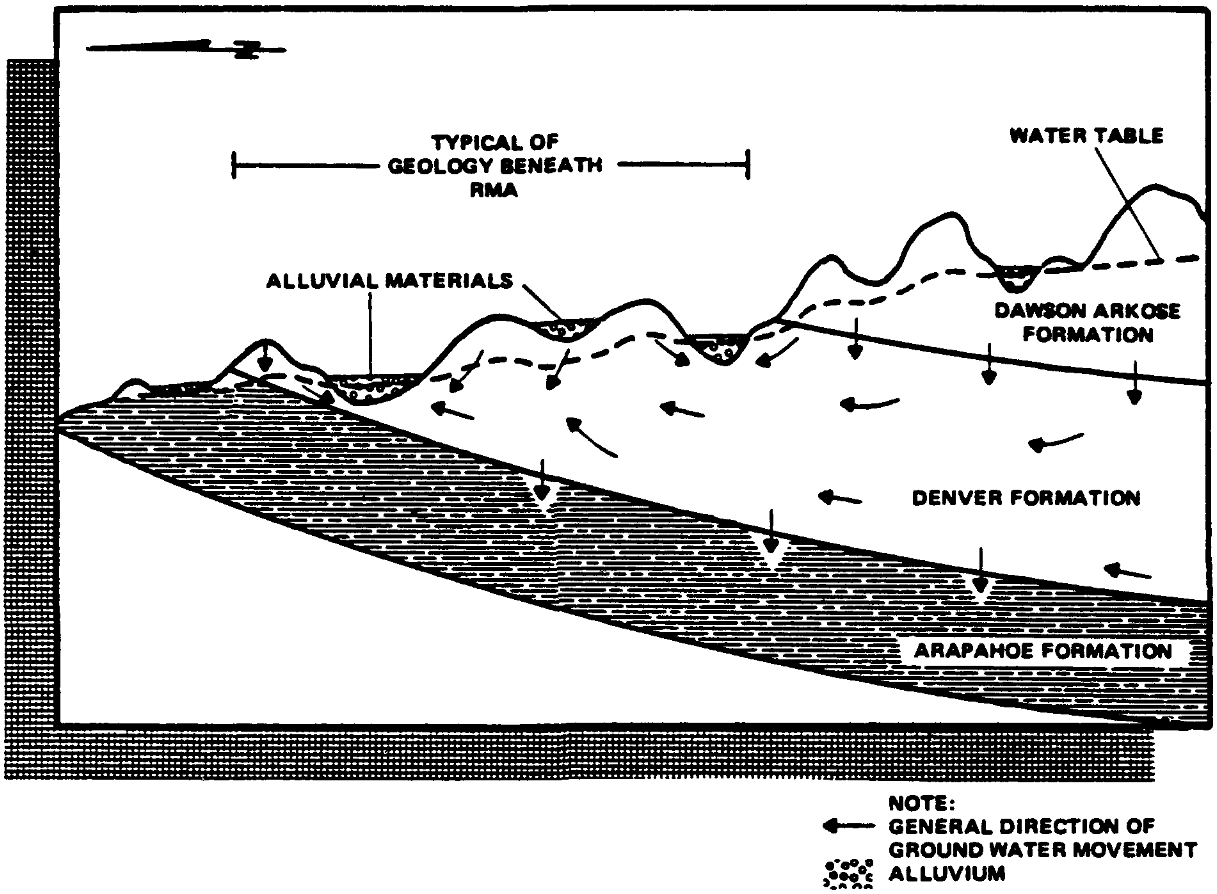


FIGURE 2-3
REGIONAL HYDROGEOLOGIC FLOW SECTION
IN THE VICINITY OF RMA
(TAKEN FROM ROBSON AND ROMERO 1981)

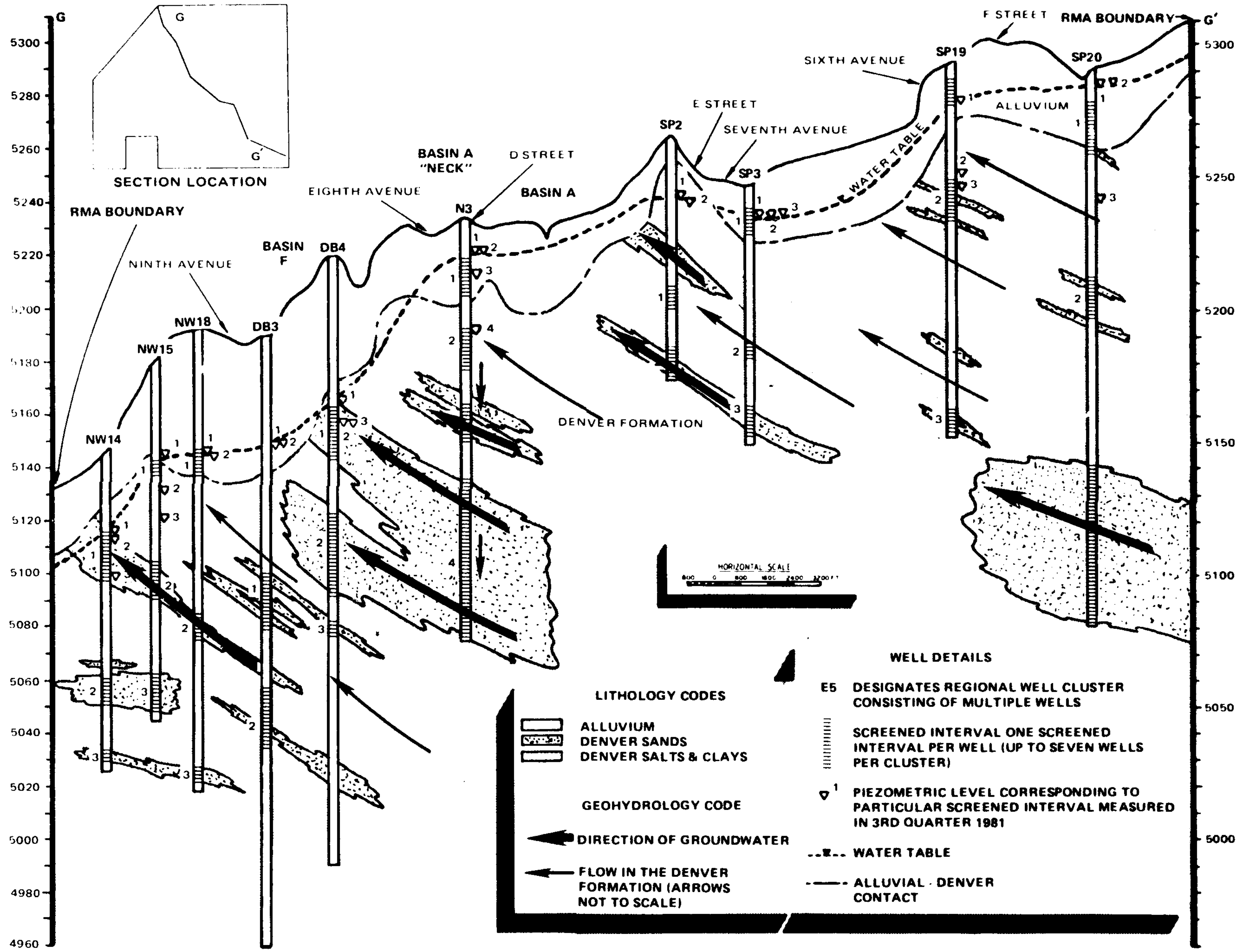


FIGURE 2-4
HYDROGEOLOGIC SECTION G-G'

To assist in understanding the ground water movement and contamination migration patterns at RMA, the configuration of the water table was mapped (Figure 2-5).

In the southern portion of the Arsenal an anomaly in the water table has dramatically affected the regional and local ground water flow patterns. A water-table mound, believed to have been enhanced by leaking water lines, has formed below the South Plants Area with flow lines radiating out from the top of the mound in all directions. A ground water divide (or no-flow boundary) has been created at the confluence of the regional flow systems and that of the mound. As a result, underflow entering RMA from the southeast is forced to turn either east or west around the South Plants Area. Water flowing south from the mound area is forced to change direction. As the regional underflow moves away from the mound, flow is toward the west to northwest and the northeast.

The overall ground water flow regime can be divided into three main components indicated by arrows on Figure 2-5. One section of flow is from the mound and west of Basin A towards the west and northwest boundaries. The second major component is from the mound through the Basin A area, through the Basin F area and toward the northwest and north boundaries, and the third component of flow is from the mound and east of Basin A toward the north boundary.

Just south of Basin F major changes in the flow pattern occur as indicated by the equipotential lines. The main component of flow bifurcates with some of the flow going west and some northwest. North of Basin F, the flow pattern can only be delineated in a general way as water-table gradients are very flat. This is caused by an abrupt increase in the permeability and/or saturated thickness north of Basin F.

Vertical ground water flow conditions also occur under the Arsenal. The results of several investigations indicate that there is significant interchange of ground water between the Denver sands and the alluvium. These conditions and the flow system are described in more detail in Appendix C.

2.3.4.3 Contaminant Migration Pathways

Key areas where contamination has occurred include the South Plants Area, Section 36 (Basin A), Basin F, and the Rail Classification Yard. To summarize the migration pathways in the ground water, a composite map of the plumes of contamination was prepared. The map, shown in Figure 2-6, illustrates the lateral distribution of different chemical species. Chemical species used to construct this map include DIMP, DBCP and DCPD.

NUMBERS ON THIS FIGURE ARE IN FEET ABOVE MSL TAKEN IN 3RD QUARTER 1981.

FIGURE 2-5
PRIMARY FLOW COMPONENTS AT RMA

BLUE SHADED AREA REPRESENTS AREAS WHERE WATER TABLE IS BELOW THE ALLUVIAL-DENVER CONTACT

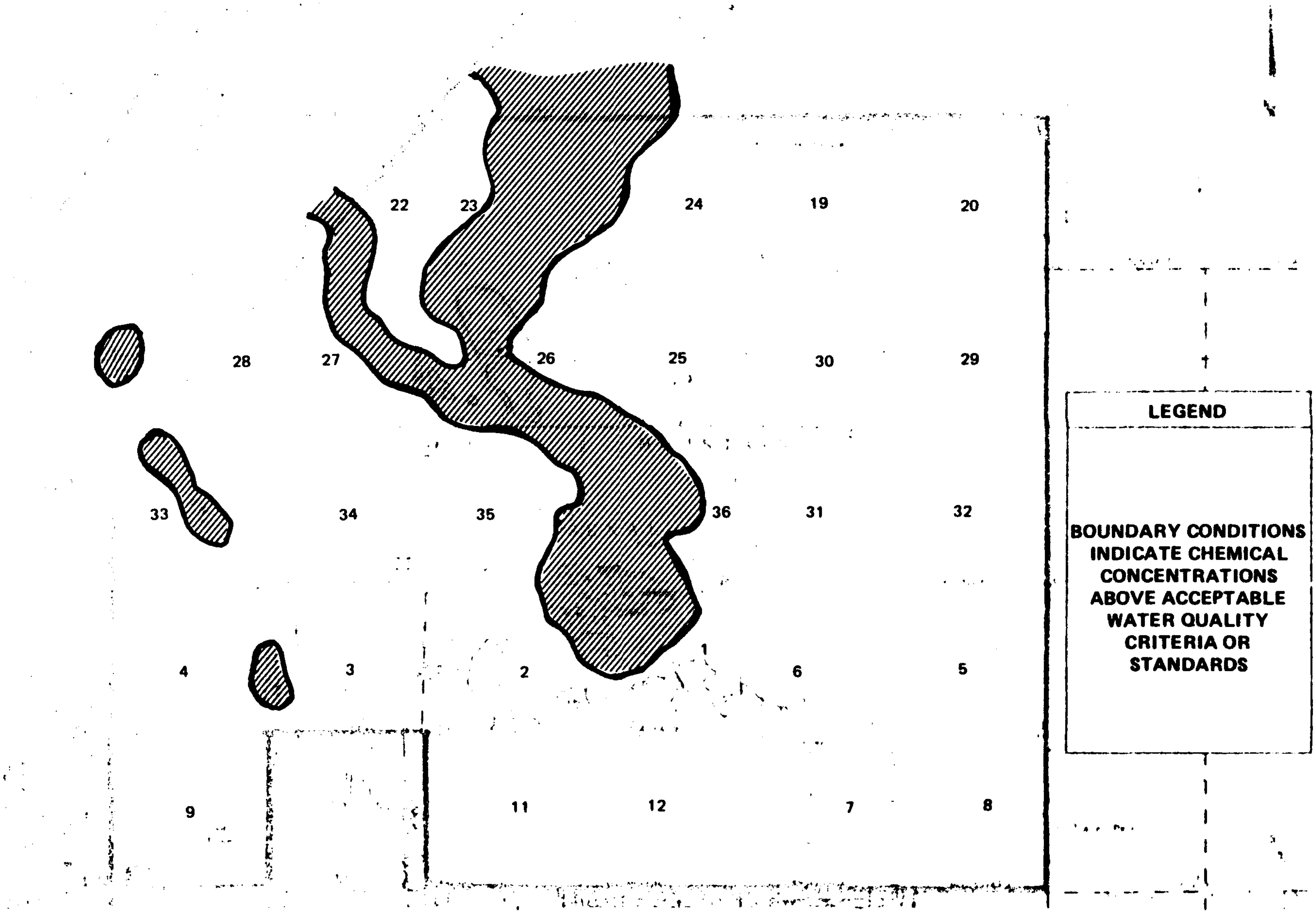


FIGURE 2-6
CHEMICAL CONTAMINATION PLUME ABOVE ACCEPTABLE LIMITS

As indicated by the contaminant plume map, there are several general contaminant migration pathways across the Arsenal. As expected, these pathways tend to follow the major ground water flow paths, as indicated in Figure 2-5. From Figure 2-6, it can be seen that the major plumes of contamination exist in the South Plants Area and Basin A. North of Basin A and towards Basin F, the contaminant plumes migrate towards the northwest boundary and the north boundary.

The northwest component of the contaminant plume migrates from the Basin A Neck area and generally follows a narrow, shallow, buried bedrock channel into Section 27, north into Section 22, and to the northwest boundary as shown in Figure 2-6. Detailed exploration to define this channel has been recently accomplished as a result of extensive investigations on the migration of DBCP. From this information it has been determined that some of the contaminants passing through the Basin A Neck area will be transported to the northwest boundary.

Another component of flow causes the contaminants to migrate toward the north, finally reaching the north boundary. This pattern is also shown on Figure 2-6.

Most of the contaminants originating from Basin F migrate to the north and northeast and are intercepted by a containment treatment system at the north boundary.

A plume of DBCP contaminated groundwater which apparently originates at the Rail Classification Yard was discovered in 1981. The Irondale DBCP barrier was completed in December, 1981. As shown in Figure 2-6, the front edge of the plume migrated across the northwest boundary of the Arsenal before the plume was intercepted.

The assessment of the hydrogeologic conditions at RMA provided the identification of sources and an interpretation of migration pathways. It also allows for estimates of any impact of the remedial action on the ground water system.

2.4 DESCRIPTION OF CONTAMINATION SOURCES

2.4.1 Introduction

Assessments have been made of the contaminant migration potential from the 165 suspected contamination sites on RMA to yield those areas which represent ongoing or potential sources of migrating contaminants[3][4]. Arsenal records, reports and aerial photos were reviewed to establish locations where contaminants may have been stored, spilled or discharged onto the ground. Field work included well drilling and ground water, surface water, sediment and soil sampling. Results of chemical analysis of Arsenal wide water samples

and selected soil samples were evaluated to establish the presence and migration of contaminants from potential contamination sources. The following are the resulting areas of concern which can be located on Figure 2-7.

2.4.2 Basin A (Section 36) and South Plants Area (Sections 1 and 2)

In 1942, the Armed Forces of the United States had a critical need for chemical filled munitions, as well as an urgent requirement for incendiary munitions. Manufacture and filling of these munitions in the South Plants Area resulted in discharge of liquid waste into the Basin A lime settling ponds and Basin A pool, located in Section 36, north of the South Plants Area*. Other industrial operations in the area included the production, munition filling and storage of mustard gas, lewisite, phosgene, white phosphorous, chlorine, incendiary mixtures, explosive button bombs, and the manufacture of pesticides by private commercial tenants. Facilities completed in 1953 in the North Plants Area which produced GB agent also utilized Basin A for liquid waste disposal.

Historical and current data provide evidence which identifies the South Plants Area as containing the most heavily contaminated ground water on RMA. The following are representative of the problems known to have occurred in this area:

a. A major spill of benzene in 1948; benzene is currently present and migrating from the area.

b. The surface disposal of waste in disposal ponds and burial pits.

c. Discharges of chlorinated pesticides and mercury into the environment through surface ditches impacting Lower Lakes: Upper Derby, Lower Derby and Ladora.

d. Plumes of contaminants with high migration potential indicated by ground water sampling and analysis.

e. Infiltration and exfiltration of contaminants from sewers provides current active pathways for contaminant drainage from the source areas.

f. Buildings with contaminated water in basements and sumps.

Because of these problems, Basin A and the South Plants Area has contributed to past and current migration of contaminants in the direction of the Arsenal boundaries.

* Basin A hereafter, is defined as the area of liquid disposal in land Section No. 36 of RMA. Basin A Neck represents a geologic formation through which the primary ground water of Basin A exits.

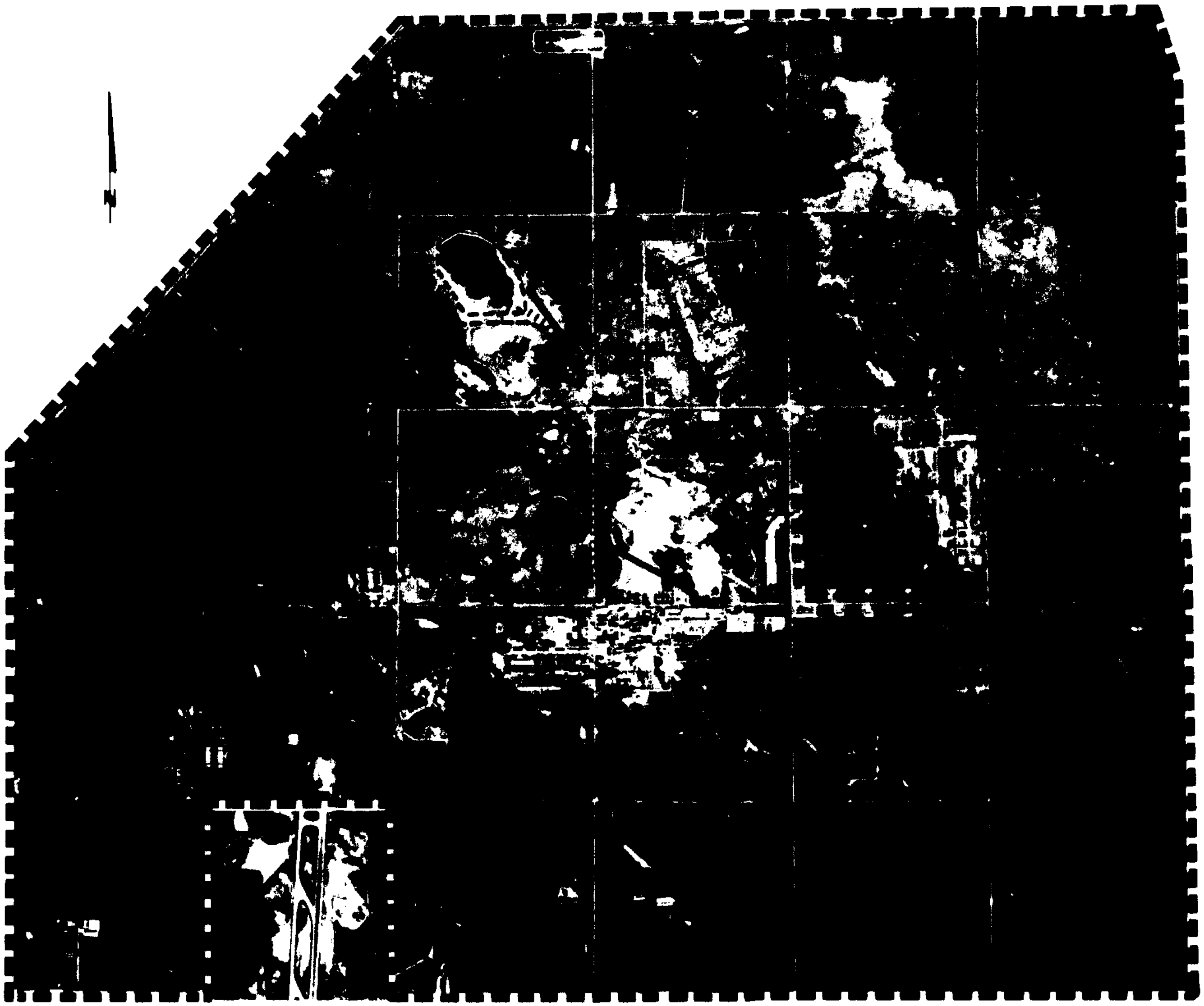


FIGURE 2-7
SUMMARY OF RMA
CONTAMINATION SOURCES

2.4.3 Basin F (Section 26)

The need for expanded waste storage facilities resulting from the manufacture of agent GB as well as the discovery of pollutants in the ground water off the northwest boundary of RMA, caused the construction of Basin F. Basin F encompasses approximately 93 acres and was constructed in 1956 with an asphalt-lined bottom protected with a nominal 12 inch thick sand layer.

Problems associated with the storage of liquid wastes in Basin F were encountered early in its operation and were caused by wave action against the shoreline that, at the time, had not been protected by riprap. In 1957, tears in the asphalt liner were found. The Basin F contents were pumped into Basin C, an unlined facility, while repairs were made to the Basin F liner and riprap was installed. No records exist to determine the impact of this pumping and repair action on the ground water environment.

Historical and current studies on Basin F have identified problems with the site. Parts of the liner whicn are torn are being exposed to the impounded liquid. Fluctuating liquid levels cause cyclical exposures of the liner to sunlight and weather conditions. Also, evidence of ground water contamination has been determined by the chemical analysis of monitoring wells immediately adjacent to the Basin.

Recent sampling and analysis of subsoil by WES/RMA, et al,[10] show that the original liner, generally, is in good condition, with some leaching noted, particularly in the southeast corner of the Basin known as "Little F". Contamination has migrated through the liner in several sample locations and is present in shallow depths beneath the basin. Areas currently beneath the liquid pool are suspect, since they could not be sampled during the recent problem definition study.

Ground water flow paths beneath Basin F are described as truncated, with the primary flow moving north toward the north boundary and a secondary smaller flow exiting the north end of the Basin in a north-northwest direction. Depth to the water table beneath the Basin varies between 40 and 50 feet in alluvial material. The saturated thickness in the alluvium is five feet or less.

Installation of the Enhanced Liquid Pool Evaporation system has recently been completed at Basin F. This project also included removal of the contaminated sewer from the Basin south to the South Plants Area. Contaminated chemical sewer material and soils were stock-piled in the Basin on a lined storage site pending final closure action.

2.4.4 Rail Classification Yard (Section 3)

In 1980 DBCP (dibromochloropropane) was detected in the Irondale community. Geochemical investigations and analysis of resultant ground water samples by the Army and Shell Chemical Company identifed a source area for the DBCP exiting the rail classification yard in Section 3 on RMA. Information provided by Shell Chemical Company confirmed that DBCP had been shipped from this area during the 1970-1975 time frame.

Additional source area studies were conducted in May 1982 that confirm that the track drainage system has been leaching DBCP from the area.

Analysis of the performance of the Irondale barrier system constructed in 1981 by Shell Chemical Company at the boundary indicates that the system has been extremely effective in controlling the plume and removing the contaminant from the alluvial groundwater leaving the RMA.

A monitoring program is presently collecting ground water data to allow for the detection of changes in DBCP levels emanating from the rail classification yard.

2.4.5 Sanitary Sewer System

In addition to providing transport of contaminants to the sewage treatment plant at the northern boundary (Figure 2-8), the sanitary sewer system has been identified as a major source of pollution. Several sections of the sanitary sewer line are below the water table in the South Plants Area. Also, numerous breaks in the pipelines of the system are present. These factors contribute to an ideal situation for infiltration and exfiltration of contaminants, particularly in the Basin A, Basin A "Neck", South Plants and Basin F Areas.

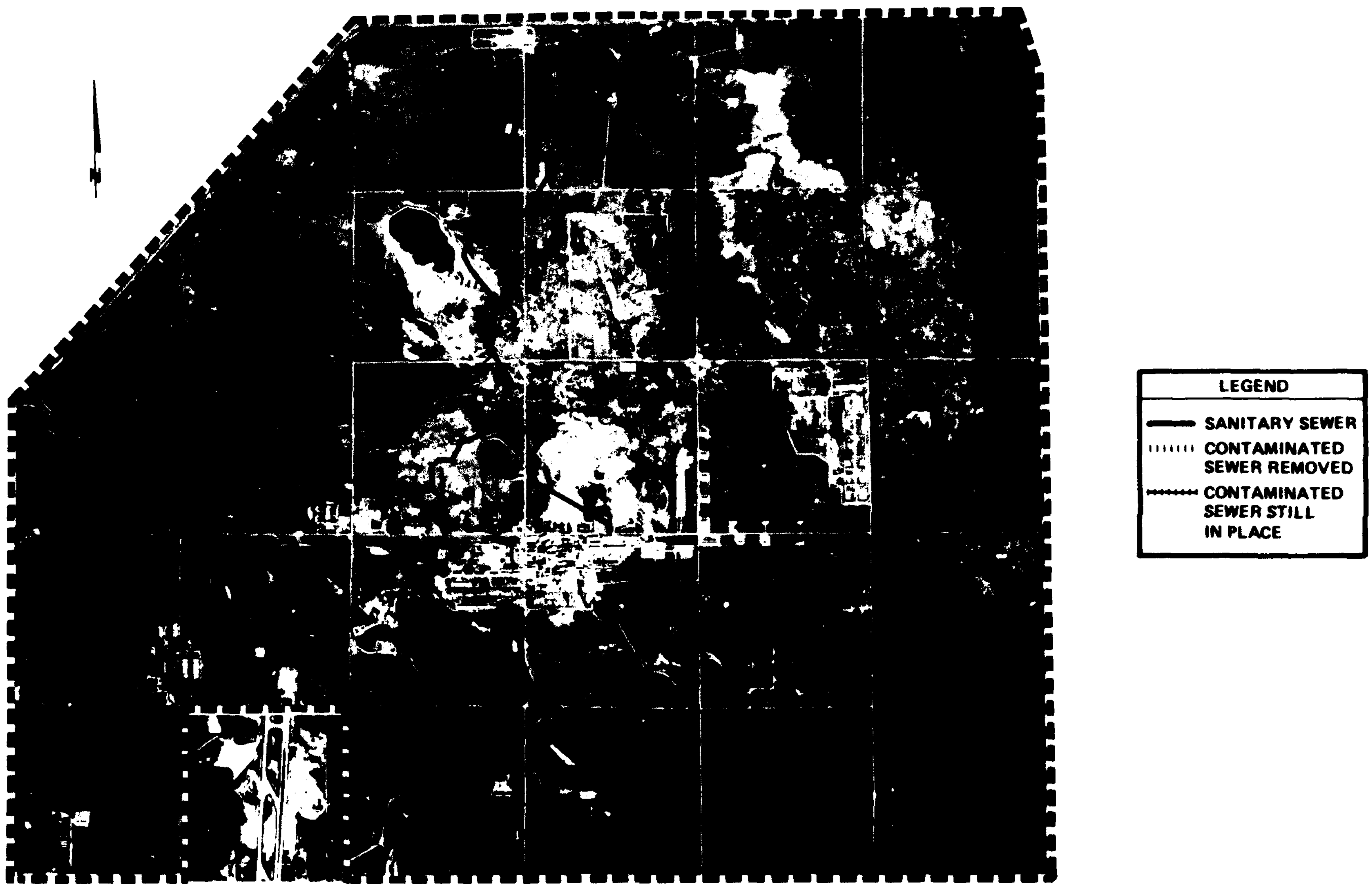


FIGURE 2-8
PLAN VIEW OF SEWER LINES

2.4.6 Chemical Sewer System

The chemical sewer system, like the sanitary sewer, was constructed many years ago to transport contaminated wastes from the manufacturing plant areas to above ground evaporation basins (Figure 2-1). Visual examination of the sewer line in the late 1970's revealed numerous leaks directly contributing to ground water contamination. This problem is intensified at several sections where the sewer line is below the water table. These factors contribute to the chemical sewer acting both as a receptor and releaser of contaminated fluids, particularily in the South Plants, Basin A and Basin F areas.

Remedial action has taken place in relation to the chemical sewer system. In 1981/82 both the Army and Shell took steps to eliminate the sewer as a migration source. The Army has removed and stockpiled in Basin F over 12,000 feet of the sewer line and its surrounding trench material from the South Plants to Basin F. At approximately the same time Shell Chemical Company completed installation of an above ground sewer system, independent of the old sewer, to serve Shell's operations in the South Plants.

2.4.7 Lower Lakes (Sections 1, 2, 11 and 12)

In the 1940's and 1950's, there was contamination of the cooling water system with chlorinated pesticides and mercury which was circulated through Upper and Lower Derby Lakes. This cooling water system utilized lake water pumped through the interconnected lake system. Recent data collected as part of the AMCCOM interim beneficial action program show that the Derby lakes continue to have residual aldrin, dieldrin and mercury contamination which is hazardous to wildlife. This situation exists even though Upper and Lower Derby Lakes were clean of contaminated sediments in 1965.

Lake bed sediments contaminated by aldrin and dieldrin were deposited in low areas along the northern edge of Sections 11 and 12 in 1965. A cap of uncontaminated soil was placed over the disposal area. Soil and ground water samples were collected in this area and checked for contamination. Four soil samples were taken in this area and contamination was found in one sample. The soil samples which were taken approximately three feet below the dredgings were negative, indicating no downward migration of contaminants into the ground water.

Vegetative uptake of the local plant life has not been ascertained. Therefore, it cannot be determined whether the dredged material is a source for contaminants migrating through the ecosystem. This area will be monitored to identify any future migration or ecological problem.

2.4.8 Basins C, D, E and G (Section 26)

Basin C, an unlined evaporation pond, received discharges from the GB Plant, large quantities of freshwater from Sand Creek Lateral, and temporarily held approximately 100 million gallons of liquid wastes while Basin F underwent lining repairs in 1957. Basins D and E, also unlined, received overflow from Basin A from 1953 until the construction of Basin F in 1956. No documentation of Basin G use is available. These four basins overlie several contamination plumes originating in the Basin A area, making it difficult to assess whether they are true sources. Chemical analyses of soil samples from the basin found traces of DIMP, CPMS, CPMSO AND $CPMSO_2$ in solvent extracts. Water extracts of soil samples resulted in below detectable limits for all parameters except CPMSO.

2.4.9 Rod and Gun Club Pond (Section 12)

Several years after the south lakes were dredged, a new pond known as the Rod and Gun Club Pond developed in a natural low area immediately south of the dredge disposal area in Section 12. This pond connects to an overflow channel from Lower Derby. At periods of high water levels in Lower Derby, water flows into the Rod and Gun Club Pond. Contamination was found in the overflow ditch and pond sediments. This contamination is the result of erosion and deposition, and is not a threat to local ground water quality.

2.4.10 GB Plants (Section 25)

The outfall from the GB Plants storm sewer flows east to First Creek. Discharge is generated from the noncontact cooling water system and from storm runoff. Historical data have shown traces of DIMP in the drainage ditch.

The surface water sample at the outfall does not indicate the presence of any contaminants originating at this site. Traces of organics were found in some soil samples. One regional well, screened in the Alluvium and located north of the GB Plants Area (E10/25018), and contains DIMP at 274 ppb. It has not yet been determined whether the plants are the source of contamination, since Basin A, a primary source, is upgradient of the area. This situation is further complicated by the proximity of the contaminated sewer lines to Well E10. Regardless of the exact source location, any DIMP migration in this area will be intercepted by the North Boundary Systems. This site will require continued monitoring.

2.4.11 Section 36 Pits

Pits in this section reportedly have been used for a variety of disposal activities, including a sanitary landfill, disposal of GB

manufacturing residue and insecticides, destruction of incendiary weapons, and disposal of nine one-ton containers of mustard and pieces of equipment.

Section 36 has been described as the most complex contaminant source and waste disposal site on RMA. A recent inhouse study [12] at RMA identified the following activities through aerial photography analysis: surface impounded liquid, burial waste, remains of surface test facilities, surface dumps, burn pits, tenant disposal trenches, grenade disposal, unexploded ordnance, and miscellaneous surface scrap. There is also an incendiary bomb testing facility in the southeast corner of the section, where unexploded ordnance may be found. Figure 2-9 is a composite of all known activities that have taken place in Section 36. This figure shows the areas used since 1948 and the magnitude of the problem.

Water quality of regional wells has been reviewed to determine the possibility of northeastward migration from this section. The results indicate no degradation of ground water quality. The ground water flow system in Section 36 is influenced greatly by the ground water mound in the South Plants Area.

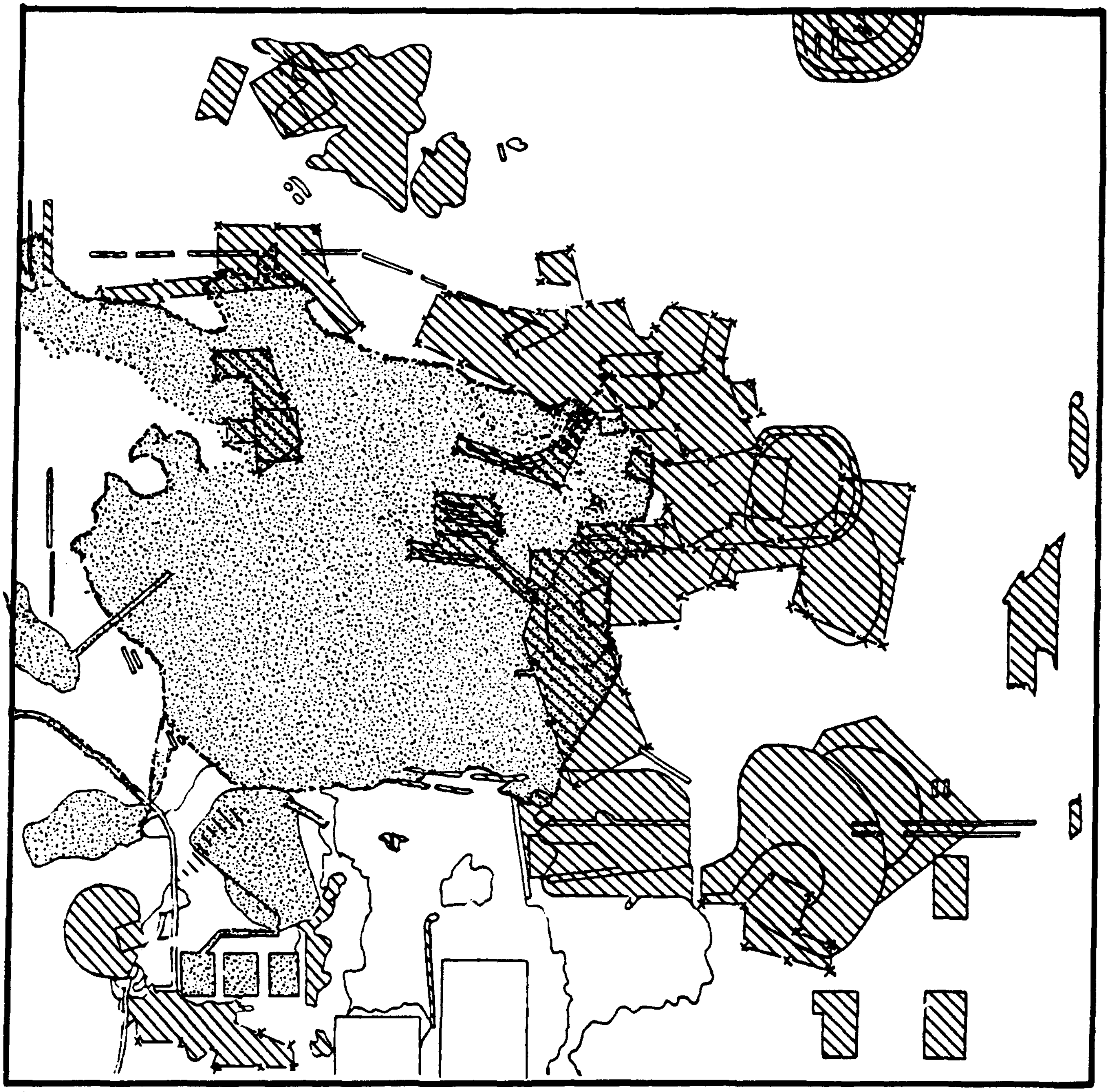
2.4.12 New Toxic Storage Yard (Section 31)

In 1969, a new toxic storage yard was established in Section 31 replacing the toxic yard in Section 6. Surface water runoff from the New Toxic Yard enters shallow ponds along First Creek and flows into a tributary of First Creek north of the ponds. GB and mustard demiliterization wastes are currently stored in the New Toxic Storage Yard.

Soil and surface water samples were collected in the vicinity of the ponds and First Creek. Ground water was sampled near the southwest corner of the yard and in three downstream regional wells. The chemical analyses of soil and water in the area indicated that the major contaminants of interest on RMA were below the detectable limit. Gas chromatography/mass spectrometric analysis indicated the presence of diethyl and dibutyl phthalates, as well as cyclohexanone. Since First Creek is intermittant, the compounds are not migrating through the surface water route at this time. This site will be monitored to detect migration during periods of continuous flow.

2.4.13 Summary of Source Areas

The studies that have been made of RMA ground water flow and chemical analyses of soil and water have been analyzed and a series of contaminant sources have been identified. Figure 2-7 is a graphic illustration of the areas of concern. The following description



CONTAMINATED AREAS RESULTING FROM LIQUID DISPOSAL OPERATIONS
CONTAMINATED AREAS RESULTING FROM SOLID DISPOSAL OPERATIONS

FIGURE 2-9
COMPOSITE MAP
OUTLINE OF DISPOSAL AREAS IN SECTION 36 SINCE 1948

summarizes each area in general terms as to the types of chemicals found:

Basin A/South Plants -	one of the most heavily contaminated areas containing wastes and raw chemicals from Army and lessees production operations. Typical chemicals include: Benzene, DCPD, DBCP, DIMP, heavy metals and various solvents.
Basin F -	an industrial, lined (but leaking) waste basin containing Army and lessees waste material. Chemicals found include: DIMP, chloride, dieldrin, endrin, sulfate, sodium, dyes, heavy metals such as copper, and many unidentified organic chemicals.
Rail Classification Yard -	a known source of DBCP that possibly resulted from leaking rail tank cars.
Sanitary Sewer System -	has interacted with contaminated ground water and serves as a transport mechanism for chemicals found in the Basin A/South Plants Area.
Chemical Sewer System -	has presumably allowed chemical contaminants to enter the ground water in manufacturing areas and near waste storage basins.
Lower Lakes -	were used as part of the industrial cooling water and were the site of a spill of aldrin, dieldrin and mercury. Most of the contamination resides in the lake sediments in parts-per-million concentrations.
Basins C, D, E and G -	received discharge from the overflow of Basin A. Analysis has shown high concentrations of DIMP, p-chlorophenylmethyl sulfur compounds, and high salt contents.
Rod and Gun Club Pond -	a pond formed when the lower lakes were dredged. Contamination is the same as the lower lakes area.

GB Plants -	were the site of GB nerve agent production and have the potential for DIMP contamination.
Section 36 Pits -	were used to burn, bury and test various ordnance for the Army. Compounds found include insecticides and their raw materials, dithiane, potential for mustard, arsenic, mercury and high salt content.
New Toxic Storage Yard -	past storage of chemical munitions and materials occurred here. Potential for contamination is small but concentrations of phthalates and cyclohexanone have been found.

The above areas will be addressed in subsequent chapters as to regulatory compliance, possible corrective actions and a proposed final source control strategy.

CHAPTER 3
LEGAL COMPLIANCE ASSESSMENT

3.1 INTRODUCTION

Chapter 2 illustrated the current definition of the contaminant migration problem at RMA. This Chapter and Appendix D provide the basis to determine the extent of Arsenal noncompliance with applicable State and Federal environmental laws pertaining to the discharge of pollutants to the environment. Pertinent environmental laws are summarized, the term "compliance" defined and each source area assessed to determine requirements for corrective action. Chapters 4 through 6 utilize these findings in developing appropriate response actions for those sources determined to be out of compliance.

3.2 OVERVIEW OF LEGAL REQUIREMENTS

Various State and Federal statutes and associated environmental regulations have been enacted which are known to be applicable to RMA. The kinds of hazardous waste management activities that are currently regulated by the US Environmental Protection Agency (EPA) or by the State of Colorado are those which result in:

a. Emission of regulated non-hazardous and hazardous air pollutants;

b. Discharge of waste water from a "point source" into Colorado surface or ground water;

c. Storage, treatment, or disposal of hazardous waste in containers, tanks, surface impoundments, waste piles, or landfills; or

d. Spills, leakage, etc. of contaminants which can pollute surface or subsurface water.

The Commander at RMA is required by law and by Executive Order to comply with these preceding Federal and State environmental statutes, insuring that the Arsenal is in full compliance. Therefore, a determination must be made as to which laws actually apply to RMA, their pertinence to release of contaminants to the environment and an identification of the responsible regulatory agency. Next, "compliance" must be defined within an RMA specific context, based upon a realistic and practical interpretation of each applicable law. Lastly, both ongoing and programmed corrective actions must be identified to establish the baseline against which compliance can be judged. The following sections of this chapter deal with each of the preceding points.

3.3 ASSESSMENT OF PERTINENT LAWS

Research of both Federal and State statutes has identified twelve environmental acts that pertain to contamination control at the Arsenal. These acts are as follows: the National Environmental Policy Act, the Federal and State Air Quality Control and Safe Drinking Water Acts; the Resoure Conservation and Recovery Act; the Comprehensive Environmental Response, Compensation and Liability Act; the State Hazardous and Solid Waste Acts; and the Migratory Bird Treaty Act. Since each of these environmental acts contains a complex set of implementing guidance rules, a detailed assessment of each regulatory area has been prepared. For the sake of brevity within Volume I, this assessment has been placed in Appendix D. Table 3-1 summarizes these findings by indicating the responsible regulating agency for each act, and providing a brief description of each act's applicability to RMA.

3.4 DEFINITION OF COMPLIANCE FOR RMA

There are a number of factors, both general and Arsenal specific, which must be considered in defining compliance for the RMA Contamination Control Program.

a. Many of the laws previously discussed have been purposefully formulated in a generalized manner to allow regulators flexibility in considering site specific conditions. Not until negotiations between the responsible parties are held, will specifics be established.

b. Overlap of legislation has sometimes occurred when several laws have been enacted to accomplish similiar purposes through different approaches. This is the case with the RCRA, the Toxic Substances Control Act and the Clean Water Acts. All these acts address toxic and hazardous substances.

c. Only recently have encompassing hazardous waste regulations, such as RCRA and CERCLA, been promulgated covering situations that exist at RMA. These environmental laws may cause a significant economic impact on owners and operators of facilities that manage hazardous substances. Finalization of these laws will probably proceed carefully, and when published, they will probably be updated periodically.

d. Record keeping procedures of waste disposal on RMA have at times been very poor, allowing only an approximated volume, location and type of contaminant release to be developed. In addition, hydrogeologic conditions beneath the Arsenal make it, in most cases, impossible to trace migrating pollutants to a particular release event.

TABLE 3-1
SUMMARY OF ACTS APPLICABLE TO CONTAMINATION CONTROL AT ROCKY MOUNTAIN ARSENAL
(Sheet 1 of 2)

Media	Source	Act	Responsible Regulating Agency	General Applicability	Specific Applicability To RMA*
All	Federal	National Environmental Policy Act (NEPA)	Environmental Protection Agency (EPA) and the Council on Environmental Quality	Directs that environmental impacts will be considered and documented for any decision process.	Governs preparation of EA's and EIS's for contamination control projects on the Arsenal.
Air	Federal	Clean Air Act	EPA Region VIII	Applies National Ambient Air Quality Standards and National Emmission Standards for Hazardous Air Pollutants to point sources.	Not directly applicable since the State of Colorado has received primacy
	State	Colorado Air Quality Control Act	Colorado Department of Health	State version of above Act.	May apply to volatile emissions from Basin F
Water	Federal	Clean Water Act	EPA Region VIII	Applies to point discharges of pollutants to navigable waters. Sets forth suggested water quality criteria.	Applies to NPDES permits for Arsenal
	Federal	Safe Drinking Water Act	EPA Region VIII	Applies to Public Water Systems providing piped water to the public. Sets forth primary and secondary drinking water criteria.	Not directly applicable since the State of Colorado has received primacy
	State	Colorado Water Quality Control Act	Colorado Department of Health	State version of Federal Clean Water Act. Applies primarily to point discharges of pollutants into State waters. State waters are defined as all waters contained in, flowing in or flowing through Colorado. The Act generally endorses the water criteria set forth by the Federal Acts.	This Act was the basis of Colorado issuing three administrative orders against the Army and Shell. Its application to non-point sources such as the inactive waste basins on RMA is unclear.
	State	Colorado Safe Drinking Water Act	Colorado Department of Health	State version of the Federal Safe Drinking Water Act.	Would apply if the Arsenal undertook to supply drinking water to the public.

* *See Appendix D for a more detailed assessment of applicability to RMA.*

TABLE 3-1
SUMMARY OF ACTS APPLICABLE TO CONTAMINATION CONTROL AT ROCKY MOUNTAIN ARSENAL
(Sheet 2 of 2)

Media	Source	Act	Responsible Regulating Agency	General Applicability	Specific Applicability To RMA
Control of Hazardous Sub-stances Into All Media	Federal	Resource Conservation and Recovery Act (RCRA)	EPA Region VIII	Sets forth policies and procedures for the handling, transportation and disposal of hazardous wastes from ongoing operations since November 1980.	Governs the closure of Basin F.
	Federal	Comprehensive Envrionmental Response, Compensation, and Liability Act (CERCLA)	Department of the Army	Provides for liability, compensation, cleanup and emergency response for hazardous substances released into the environment. Also controls the cleanup of inactive waste disposal sites	This Act applies to all of the inactive waste disposal sites on RMA. The National Contingency Plan provides guidance on the nature and extent of response actions. Army actions are required to be consistent with the NCP
	State	Colorado Hazardous Waste Act	Colorado Department of Health	Establish siting rules for hazardous waste disposal sites and designate the Department of Health as the responsible agency for hazardous waste management in the State of Colorado.	This Act would require the Arsenal to procure a Certificate of Designation to operate a hazardous waste disposal site unless a federal permit under RCRA is obtained before the state receives primacy
	State	Colorado Solid Waste Act	Colorado Department of Health	Establishes permitting procedures for solid waste disposal sites.	This Act would require the Arsenal to obtain a Certificate of Designation before operating a solid waste disposal site
Wildlife	Federal	Migratory Bird Treaty Act of 1918	U.S. Department of Wildlife and Colorado Department	Precludes hunting or killing of select migrating birds except as permitted during open hunting seasons by licenced individuals	Applies to select migratory birds being killed by contact with contaminated liquids in Basin F

e. Most of the inactive waste disposal sites on the Arsenal are regulated separately from ongoing or active facilities.

f. Some of the contaminants are associated with Army activities, some with lessee activities and others are commonly used in the private sector and are found as background. Final regulatory guidelines have not been established for several contaminants that are unique to RMA.

These preceding factors make it impractical to provide a complete definition of compliance. Some specific compliance requirements that can be identified for RMA include:

- o Preparation of environmental documentation in accordance with National Environmental Policy Act (NEPA).

- o Application for air and water discharge permits from point sources (if required).

- o Closure of Basin F.

- o Elimination of migratory bird contact with lethal, contaminated liquids.

However, more important compliance requirements which remain generalized, rather than specifically defined, include:

- o Need and extent of additional action to address the Colorado Administrative Order requiring sources of contamination to be cleaned up and controlled.

- o Need and extent of action dealing with volatile emissions from Basin F and windblown dust transport from Basin A

- o Need and extent of action dealing with contaminated water migrating from non-point sources, such as the South Plants and Basins A through F.

- o Need and extent of action dealing with release of contaminants to the environment from inactive waste disposal sites.

Time is not available for detailed guidance to be formulated clarifying each of the regulations found to lack specifics. Contamination control must proceed at RMA with response actions being proposed. The response actions proposed must be based upon a realistic and practical interpretation of compliance, incorporating Arsenal specifics. This document will approach the definition of compliance in this manner.

One characteristic pervades the listing of generalized compliance requirements above. All deal with release of contaminants to the public or environment. This release may take the form of direct human contact, indirect human contact through the ingestion of contaminated water and foodstuffs or inhalation of contaminants in air and environmental stress due to the presence of pollutants in contact with the ecologic regime.

An important factor must be considered in applying the preceding definitions of release to site specifics of the Arsenal. RMA represents a secure Federal installation within the State of Colorado. This has many implications on the definition of compliance requirements to the Arsenal. Due to RMA's chemical agent mobilization mission, public access to the site is controlled through the use of perimeter security. Access to internal contaminated sites such as Basin F and Basin A are further controlled by the need to obtain specific permission for entry into these areas. On post worker contact with contaminated ground water and surface water for purpose other than sampling is restricted. Finally, hunting and fishing on the Arsenal for consumptive use has been discontinued.

Tempering the definition of "release" with the Arsenal specifics, a definition of compliance has been developed and is presented in Table 3-2. Listed in this Table are the eleven essential steps that will enable the Army to achieve legal compliance.

3.5 BASELINE CONTROL ACTIONS

Numerous pollution abatement efforts have been implemented over the last several years responding to the need for contamination control at RMA. In addition, there are several corrective efforts that are in various stages of implementation. The baseline concept considers both ongoing actions and response efforts that are programmed or planned and is therefore made up of the following actions (see Figure 3-1):

a. Expanded North Boundary System (operating).

b. Northwest Boundary System (programmed).

TABLE 3-2
COMPLIANCE ELEMENTS

To achieve legal compliance at RMA concerning release of contamination to the environment, the Army must:

- Continue the consideration of environmental impacts of proposed contamination control strategies in decision making via preparation of environmental documentation.
- Maintain up to date NPDES permits for point discharges to surface water flowing off RMA.
- Close Basin F in accordance with 40 CFR Part 265 and applicable Colorado Hazardous Waste Regulations.
- Eliminate death to migratory wildlife due to contact with contaminated liquids and sediments on the installation.
- Eliminate RMA as a source of DIMP and DCPD to the off-post public.
- Determine the geographical extent of DIMP and DCPD.
- Ensure that volatile emissions from Basin F and windblown dust transport from Basin A are within human health criteria for protection of on-post workers and the off-post public.
- Ensure that water leaving RMA meets all applicable water quality standards. Attempt to meet suggested guidelines, considering technological and economic realism.
- Consider corrective action through the form of removal or remedial action for each inactive waste disposal site currently releasing contaminants to the environment (primary source). The form of response action should consider the most cost effective action to minimize environmental impacts.
- Ensure that unacceptable human contact is minimized and monitoring is implemented to detect movement of contaminants from inactive waste disposal sites which possess a potential to release contaminants to the environment (secondary sources).
- Maintain restrictions at RMA on 1) access to contaminated surface sites, 2) use of contaminated ground water and surface water and 3) hunting and fishing contaminated wildlife.
- Operate and close sanitary landfills in accordance with applicable provisions of the Colorado Solid Waste Act.

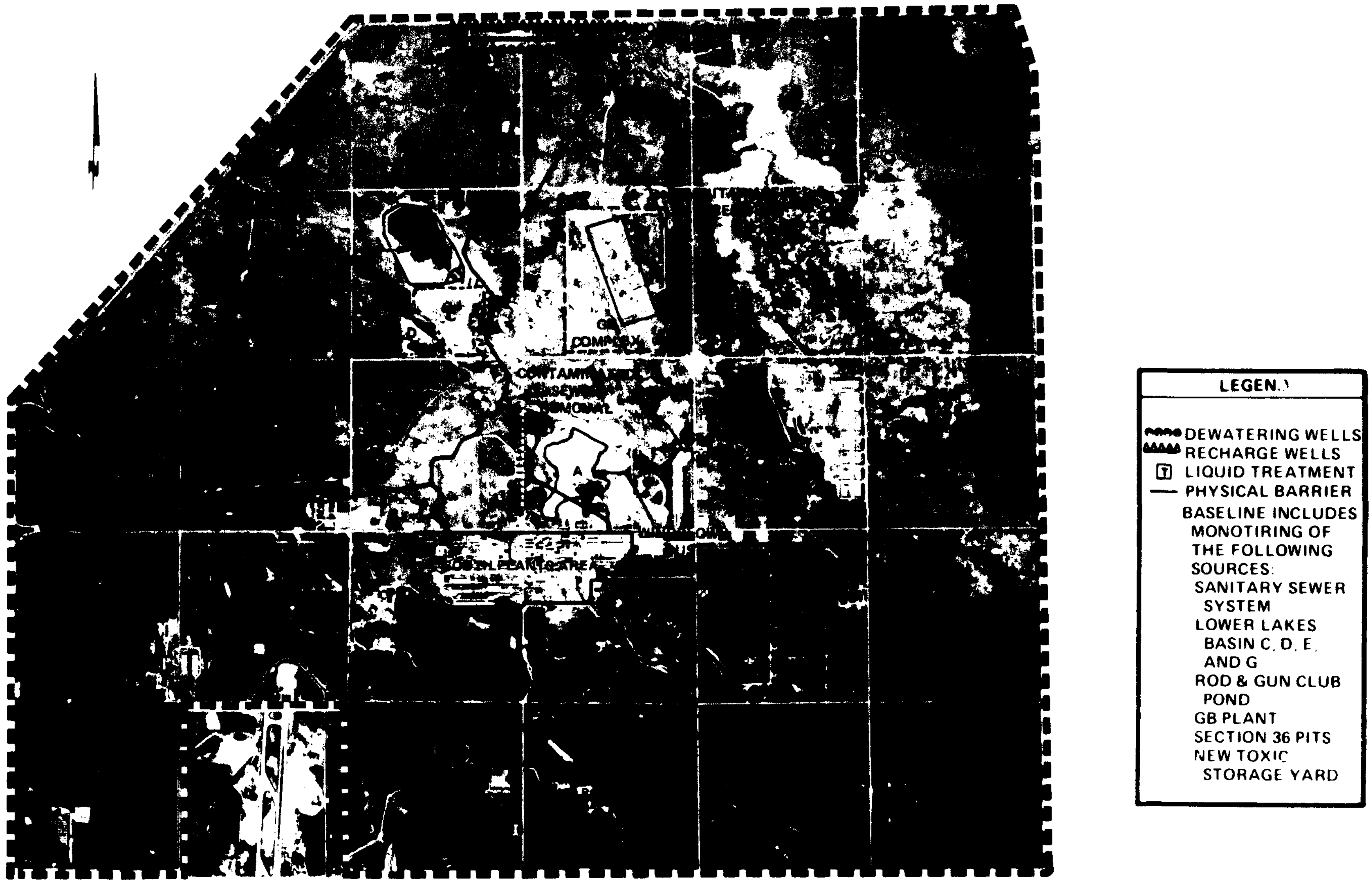


FIGURE 3-1
BASELINE FOR PHASE III

c. Irondale System (operating).

d. Basin F Evaporation (operating).

e. Vitrified Clay Contaminated Sewer Removal (complete).

f. Sanitary Sewer Removal/Upgrade (planned).

g. Basin A Windblown Dust Control (ongoing).

h. Lower Lakes Sediment Removal (planned).

i. Plugging of deep well (planned).

j. Secondary Source Area Monitoring (planned).

Baseline actions which are either programmed, planned or in progress include several important efforts that will be referred to in the following sections. A summary of each is provided at this point. The Northwest Boundary System will consist of a 2600 feet long hydrological dewatering/treatment/recharge containment scheme placed adjacent to the northern portion of the northwest boundary to prevent the release of DBCP from RMA. Sanitary sewer actions will entail 1) removal and disposal of the existing sanitary sewer line running to the North Boundary Sewage Treatment Plant, 2) repair of existing sewer lines within the South Plants Area and 3) installation of three package sewage systems to serve the Headquarters, South Plants and North Plants. The Basin A windblown dust control program consists of spraying synthetic polyvinyl acetate dust palliative to 70 acres of the exposed dry areas within Section 36. Sprayed areas will be monitored to determine the effectiveness of the spray palliative in controlling dust emissions for treatment, and additional acreage will be considered if warranted. Lower Lakes sediment removal includes removal of one to two feet of contaminated sediment from Upper and Lower Derby Lakes. The abandoned 12,000 foot injection well will be plugged with a cement/bentonite admixture to prevent any possibility of cross contamination between the near surface and deeper potable aquifers. Secondary source area monitoring is ongoing, but will be expanded to provide an early warning if release of contamination to any mobile media occurs.

3.6 COMPLIANCE ASSESSMENT

Now that a definition of compliance has been prepared, and baseline actions identified, a compliance assessment can be made for RMA. To aid in presentation, Table 3-3 has been prepared summarizing each of the elements of compliance developed in Section 3.4. Furthermore, the Table provides a brief statement as to the status of efforts to achieve compliance and a determination as to the present compliance mode of the Arsenal.

TABLE 3-3
COMPLIANCE ASSESSMENT FOR
ROCKY MOUNTAIN ARSENAL
(Including Baseline Actions)
(Sheet 1 of 3)

Compliance Element	Status of Efforts to Achieve Compliance Includes Baseline Actions	Assessment		Applicable Act[1]
		Compliance	Non Compliance	
Continue consideration of environmental impacts of proposed contamination control strategies in decision making.	Each control strategy implemented to date has been documented in appropriate environmental documentation. Future control strategies such as those contained in this report will consider environmental impacts in the decision making process.	X		1
Maintain up to date NPDES permits for point discharges to surface water flowing off RMA.	Two point discharges are permitted under the NPDES permit system at RMA. The first is the sewage treatment plant while the second is the surface outfall from the North Plants. Both discharge to First Creek. No other point discharges have been identified at RMA.	X		3
Close Basin F in accordance with 40 CRF Part 265.	An initial closure plan was submitted by RMA in October 1981. A draft final closure plan will be prepared and submitted prior to April 1983 consistent with a memorandum of agreement with EPA which constitutes a Federal Facility Compliance Agreement.		X	4 & 8
Eliminate death to migratory wildlife due to contact with contaminated liquids and sediments on the installation.	Warning devices to scare away water fowl from Basin F have been in operation since the mid 1970's		X (Basin F)	6
Ensure that a mechanism is in place to eliminate RMA as a source of DIMP and DCPD to the public.	The marshy bog at the North Boundary, original point discharge of DIMP and DCPD, was bermed to eliminate surface runoff from RMA. Since that time a pilot North Boundary ground water control system was expanded in 1980 to totally eliminate contaminated ground water flow off the North Boundary of RMA. To date the system appears to have been effective in accomplishing this goal. No other migration pathway of DIMP or DCPD above standard has been discovered off the installation.	X		3
Ensure that a monitoring program is in place to determine the geographical extent of DIMP and DCPD	A 360° monitoring program is in place at RMA to determine the extent of contamination in ground and surface water both on and off the installation. DIMP and DCPD are part of this program. Participants in this effort are the State of Colorado, Shell Chemical Company and RMA.	X		3

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TABLE 3-3
COMPLIANCE ASSESSMENT FOR
ROCKY MOUNTAIN ARSENAL
(Including Baseline Actions)
(Sheet 2 of 3)

Compliance Element	Status of Efforts to Achieve Compliance Includes Baseline Actions	Assessment		Applicable Act[1]
		Compliance	Non Compliance	
Ensure that volatile emmissions from Basin F and windblown dust transport from Basin A are within human health criteria for on-post workers and the off-post public.	The USAEHA Study (19) indicates that operation of enhanced evaporation system at Basin F will not affect the overall lifetime cancer risk to the general population. Problems associated with windblown dust from Basin A have been studied previously. Data substantiated that contaminated particulates were moving away from the basin and could affect occupation health on the Arsenal. No evidence of off-post migration was defined. Recent application of a soil stabilizer to Basin A should bring this problem into acceptable limits.	X Volatiles from Basin F) X (Windblown dust from Basin A)		2 & 5
Ensure that water leaving RMA meets all applicable water quality criteria.	Control systems are in place at the North Boundary and upstream from Irondale at the Northwest Boundary to contain and treat contaminated groundwater to acceptable levels. A section along the northern portion of the Northwest Boundary has been determined to contain unacceptable levels of contaminated ground water. Design is underway to establish a ground water control system to correct this remaining deficiency and thus achieve total compliance. The only perennial surface water discharge from RMA has been periodically monitored and found to be within acceptable guidelines.	X		3 & 5
Consider corrective action through the form of response action for each inactive waste disposal site currently releasing contaminants to the environment. (Primary Sources)	Contaminant migration surveys have been completed for every source on RMA which possessed a potential for release of pollutants to the environment via a mobile media. This report addresses the necessary response action (Chapters 4 - 6) for inactive waste sites currently releasing contaminants.		X	5
Ensure that unacceptable human contact is minimized and monitoring is implemented to detect movement of contaminants from inactive waste disposal sites which possess a potential to release contaminants to the environment. (Secondary Sources)	Contaminant migration surveys have been conducted for every source on RMA which possessed a potential for release of pollutants to the environment via a mobile media. Additional monitoring actions required to detect contaminant movement from the inactive waste sites with a potential to release contaminants will be established as part of baseline actions.	X		5

TABLE 3-3
COMPLIANCE ASSESSMENT FOR
ROCKY MOUNTAIN ARSENAL
(Including Baseline Actions)
(Sheet 3 of 3)

Compliance Element	Status of Efforts to Achieve Compliance Includes Baseline Actions	Assessment		Applicable Act[1]
		Compliance	Non Compliance	
Maintain restrictions at RMA on: 1) Access to contaminated surface sites, 2) Use of contaminated groundwater and surface water, and 3) Hunting and Fishing	These restricitve controls are in place at RMA.	X	9 & 10	3 5 9 & 10
Operate and close sanitary landfill(s) in accordance with applicable provision of the Colorado Solid Waste Act	The sanitary landfill at RMA is being operated in accordance with applicable Colorado statutes. It will be properly closed upon termination of waste introduction.	X		10

[1] Note:
1. National Environmental Policy Act.
2. Colorado Air Quality Control Act.
3. Colorado Water Quality Control Act.
4. Resource Conservation and Recovery Act.
5. Comprehensive Environmental Response, Compensation and Liability Act.
6. Migratory Bird Treaty Act of 1918
7. Federal Clean Water Act
8. Colorado Hazardous Waste Act
9. Colorado Safe Drinking Water Act
10. Colordo Solid Waste Act

The compliance assessment demonstrates that activities to date represent a positive attempt by the Army to control contaminant release at RMA. Out of twelve compliance elements, nine are in compliance or close to being in compliance. Those that are out of compliance have had sufficient definition of the associated problems (detailed in Chapters 4 through 6 of this report) to allow development of appropriate corrective actions.

3.7 SOURCE AREA COMPLIANCE STATUS

Implementation of an overall strategy of contamination control to meet the program goal of compliance can now be subdivided into (1) the continuation of those actions that have brought the Arsenal into compliance to date and (2) the development of additional actions necessary to address the following three areas of noncompliance:

a. Closure of Basin F.

b. Elimination of migratory wildlife contact with contaminated liquids and sediments on the Arsenal.

c. Initiation of response actions for each primary inactive waste disposal site currently releasing contaminants to the environment.

In order to develop specific control technologies in Chapter 4, a determination must first be made as to the applicability of the three noncompliance elements listed above to the sources delineated in Chapter 2. The results of this assessment are summarized in Table 3-4 and are discussed as follows.

3.7.1 Basin A/South Plants

Basin A and the South Plants primary source areas may be appropriate for response under CERCLA due to numerous spills and discharges of hazardous substances that have occurred in the area. Sampling and analysis results demonstrate that contaminants are being released to the environment and migrating away from the site. Alternatives for the control of this release are presented later in this report.

TABLE 3-4
SOURCE AREA COMPLIANCE
STATUS FOR RMA
(After Completion of Baseline Actions)

Source Area	Out of Compliance With The Following Elements			In Compliance With All Compliance Elements
	Closure of Basin F According To RCRA Regulations	Elimination of Migratory Wildlife Contact with Contaminated Liquids and Sediments	Initiation of Response Actions for Each Primary Inactive Waste Disposal Site	
Basin A/South Plants			X	
Basin F	X	X		
Rail Classification Yard			X	
Sanitary Sewer System				X
Chemical Sewer System				X
Lower Lakes				X
Basins C, D, E and G				X
Rod & Gun Club Pond				X
GB Plant				X
Section 36 Pits				X
New Toxic Storage Yard				X
Northwest Boundary				X

3.7.2 Basin F

Basin F is an approved surface impoundment operating under RCRA interim status. However, the basin is procedurally out of compliance with the RCRA regulations because it does not have an approved closure plan. RMA has entered into a Memorandum of Agreement (MOA) with EPA and Colorado which includes a schedule for submission of a closure plan. The MOA constitutes, and is in lieu of, a Federal Facility Compliance Agreement for this source to the extent the closure program is consistent with RCRA. The Basin is also out of compliance with the Migratory Bird Treaty Act of 1918, due to the presence of a hazardous fluid, which migratory wildlife contact, even with the use of "scare devices".

3.7.3 Rail Classification Yard

The Rail Classification yard may be appropriate for response under CERCLA. Spills of hazardous substances are assumed to have occurred in this area, as evidenced by downstream ground water sampling and analysis results. Response action may be required to mitigate further release of contaminants into the environment.

3.7.4 Sanitary Sewer System

Once baseline actions are complete, the sanitary sewer system will no longer be in need of response action under CERCLA. Previous spills and discharges into the sewer line have allowed the system to act as a conduit of contamination toward the north boundary.

3.7.5 Chemical Sewer System

Remedial actions taken to date on the chemical sewer have eliminated this area as an active source. Over 12,000 feet of sewer line and its surrounding trench material has been excavated. Sewer line remaining within the manufacturing complexes have been plugged. Chemical wastes are now handled in separate sealed systems.

3.7.6 Lower Lakes

The lower lakes provide an excellant sanctuary for migratory wildlife. Previous spills of pesticides in the use of the lakes as part of the cooling water system has resulted in contaminated sediments. Foraging wildlife that come in contact with the material are likely to assimilate pollutants into their bodies, and hence into the food chain. Therefore, the lower lakes may not have received appropriate response under CERCLA until baseline actions are completed. Percolation of lake water through the contaminated sediments may provide a potential pathway for contaminant migration. However, samples obtained to date had failed to confirm this. Monitoring will be continued to verify that there is no release of any contaminants from beneath the lakes or the residual dredge spoil areas.

3.7.7 Basins C, D, E and G

Basins C, D, E and G have been intermittently operated in conjunction with Basin A during the 1940's and early 1950's. Analysis of samples taken from soils within these basins detected residual chemical compounds characteristic of fluid placed in Basin A. Considering their intermittent use and length of time since last used, these basins are considered a potential source of release requiring monitoring as part of baseline operations.

3.7.8 Rod and Gun Club Pond

The Rod and Gun Club Pond connects to Lower Derby via an overflow channel. Contamination has been found in sediments along the channel and within the pond. Therefore, percolation of surface water represents a potential migration mechanism which must be monitored as part of baseline operations.

3.7.9 GB Plant

Traces of DIMP contamination have been detected in soil samples taken from beneath the surface outfall from the GB Plant. Additionally, small concentrations of DIMP have been detected in down gradient wells. An assessment cannot be made as to whether the plants are the source of ground water contamination, since upgradient samples from Basin A also show high concentrations of DIMP. Although the GB plant may at one time have been a source, it is unlikely that it is the current release point for unacceptable water quality at the north boundary. Since the potential exists for future release, the site will require monitoring as part of baseline operations.

3.7.10 Section 36 Pits

By definition, the Section 36 pits do not include Basin A or its appurtenance. These pits, used for various waste disposal activities, are principally located along the north and west portions of the section. Any release of contaminants from these covered pits would take the form of leachate to the water table. Ground water flow beneath this area is to the northwest. Water quality of regional wells installed in the flowpath indicate no degradation of ground water quality. Since the waste has a potential for future release, the site will require monitoring as part of baseline operations.

3.7.11 New Toxic Storage Yard

Ongoing storage of demilitarization wastes in the new toxic storage yard represents a continuing potential for contaminant release to tributaries leading to First Creek. Recent sampling and analysis did not reveal any ongoing migration. Monitoring will be required.

3.7.12 Northwest Boundary

A section along the northern portion of the northwest boundary represents the only remaining avenue of contaminant flow from RMA that is above guidelines. When this section is controlled, compliance with the Colorado Water Quality Control Act will be achieved. Design is underway for a combined hydrological and physical containment/treatment system at this site.

CHAPTER 4
DEVELOPMENT OF CONTROL STRATEGY COMPONENTS

4.1 INTRODUCTION

The previous Chapters have provided a summary of the technical and regulatory information pertinent to the RMA source control program. An interpretation of these data has led to the identification of principal sources on RMA and a determination that the Arsenal is out of compliance with State and Federal environmental regulations. This Chapter will describe the options available for response actions at each source area determined to be out of compliance with the environmental regulations in Chapter 3 and will identify the viable strategies management may consider to bring RMA into environmental compliance. The following sections describe the rationale for generating the most viable alternatives for controlling contaminant migration at RMA.

4.2 CATEGORIZATION OF RESPONSE ACTIONS

Chapter 3 has identified the elements which must be addressed to bring RMA into compliance with environmental regulations applicable to the Contamination Control Program. In one noncompliance area, closure of Basin F, development of appropriate response actions can be accomplished within well defined bounds through the use of performance or design criteria specified in the RCRA regulations. However, the remaining two non-compliance elements and their corresponding regulations do not specify guidance on which to base control strategy development. Therefore, this Chapter will accomplish its objective through two parallel paths.

4.2.1 Essential Actions

Those required response efforts which are clearly identified in the regulations thus allowing a definitive selection of applicable remedies, will be addressed first. Closure of Basin F falls into this category.

4.2.2 Discretionary Actions

Those response efforts which are based upon generalized environmental legislation thus allowing a wide range of possible remedies, will be addressed through the use of a hierachial methodology later in the Chapter. Corrective measures at Basin A/South Plants and the Rail Classification Yard called for under CERCLA fall into this category. As stated in Chapter 3, CERCLA is the most recent law passed by

Congress dealing with hazardous wastes found at the Arsenal. President Reagan's Executive Order, delegating much of the implementing authority, to the Department of Defense for its own facilities, focuses discretion in this area in the Department of Defense. Development and selection of appropriate response actions for these sites are therefore discretionary, based upon minimizing cost and maximizing environmental effectiveness.

4.3 STRATEGY COMPONENT SELECTION FOR ESSENTIAL ACTIONS AT BASIN F

Closure of Basin F must be accomplished according to guidance specified in the RCRA regulations. As a surface impoundment, deactivation of Basin F will be governed by regulations set forth under either Part 264 or 265 depending on the date of waste disposal termination. If all waste introduction to the surface impoundment is stopped prior to 26 January 1983, as in the case of Basin F, then performance criteria within Part 265 will apply. Otherwise design criteria within Part 264 will prevail. (A more complete description of these conditions for closure is found in Appendix D).

RCRA Part 265 specifies two methods for closure of a surface impoundment. Either all contaminated materials (residual liquid and sludge, any liners and underlying soils) must be removed and decontaminated or the site must be closed as a hazardous waste landfill. The specific design requirements for closure as a landfill are, in general, negotiable. However, at a minimum, the remaining free liquid must be treated (stabilized) or dried to support a final cover.

Extensive problem definition and technology development studies have been performed on Basin F during the last five years. These efforts have provided a firm data base for the development and selection of closure strategy components. Liquids and sediments contained in the basin, soils underlying the dry portion of the Basin, and ground water from numerous wells placed around the Basin have been sampled and analyzed to establish a three dimensional profile of contaminant distribution at Basin F. Laboratory and pilot scale treatment studies were performed on promising decontamination technology (e.g. incineration, wet air oxidation, adsorption, oxidation, fixation and solvent extraction) to establish feasibility and associated resource requirements.

Results of these efforts have eliminated decontamination as a viable alternative for Basin F closure. Either: (1) technical problems associated with the complex waste mixture yielded the processes unfeasible (e.g. fixation, oxidation, adsorption); (2) lead time for technology development caused the overall strategy implementation time to exceed study constraint of FY88 project implementation (e.g.

wet air oxidation); or (3) costs were prohibitively high (e.g. incineration). Therefore the Army is left with only two alternatives for Basin F closure: contaminated wastes/soil removal to a RCRA approved disposal site or closure of the site as a hazardous waste landfill. The RCRA approved site could be a future permitted site on RMA or within a commercial disposal facility off RMA.

4.4 OVERVIEW OF STRATEGY COMPONENT SELECTION METHODOLOGY FOR DISCRETIONARY ACTIONS AT BASIN A/SOUTH PLANTS AND THE RAIL CLASSIFICATION YARD

4.4.1 Strategy Hierarchy

A hierarchical system has been established for the development and evaluation of discretionary strategies (Figure 4-1). The hierarchy approach provides:

a. Strategy discussion within a common set of nomenclature.

b. Illustration of the logical expansion of each strategy.

c. Strategy development approach at progressively greater levels of detail rather than development on the basis of a favorite or more familiar technology.

d. Assurance that all viable strategy components are identified.

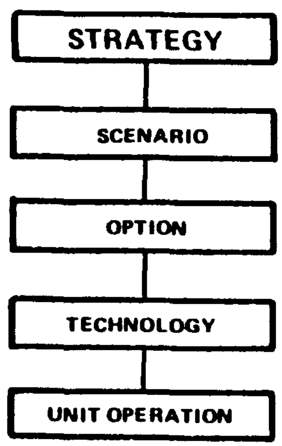
Each strategy is divided into four hierachical levels termed scenario, option, technology, and unit operation. The definition given to each of these levels, along with an example, is noted in Figure 4-1.

4.4.2 Summary of Methodology

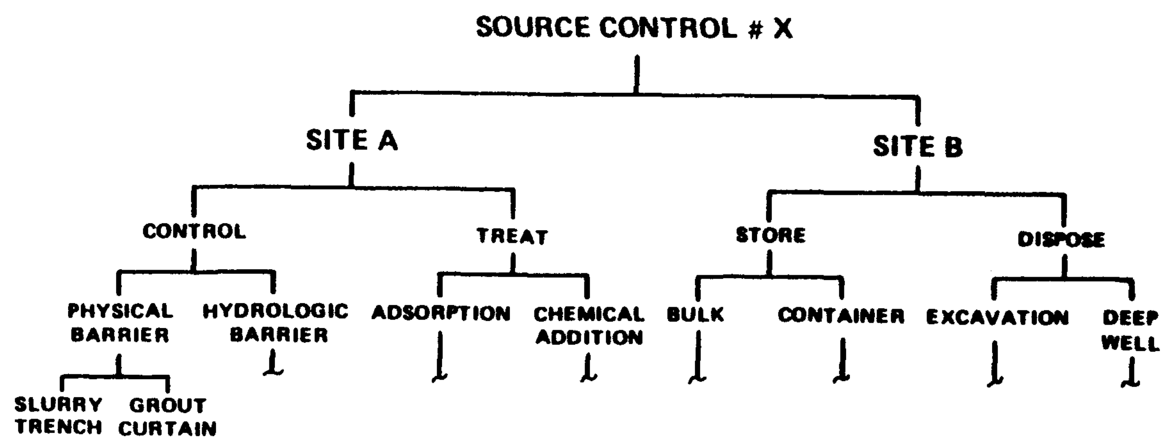
A seven step methodology was used to provide the basic framework for discretionary strategy development. Figure 4-2 illustrates the procedure.

The hierarchical system discussed in Section 4.4.1 formed the basis of stepping through strategy component evaluation. One starts at the most general level (strategy categorization), and proceeds down to the lowest level (technology selection), eliminating impracticable or unworkable alternatives.

NOMENCLATURE



EXAMPLE



DEFINITION

- STRATEGY - SYSTEMATIC PLAN OF ACTION FOR MULTIPLE SOURCE AREAS
- SCENARIO - OUTLINE PLAN FOR A SPECIFIC SOURCE LOCATION
- OPTION - CHOICE TO CONTROL/TREAT/STORE/DISPOSE/MONITOR
- TECHNOLOGY - APPLIED SCIENTIFIC PROCESS
- UNIT OPERATION - FUNCTIONAL METHOD FOR ACHIEVING PRACTICAL APPLICATION OF TECHNOLOGY

FIGURE 4-1
SCHEME HIERARCHY

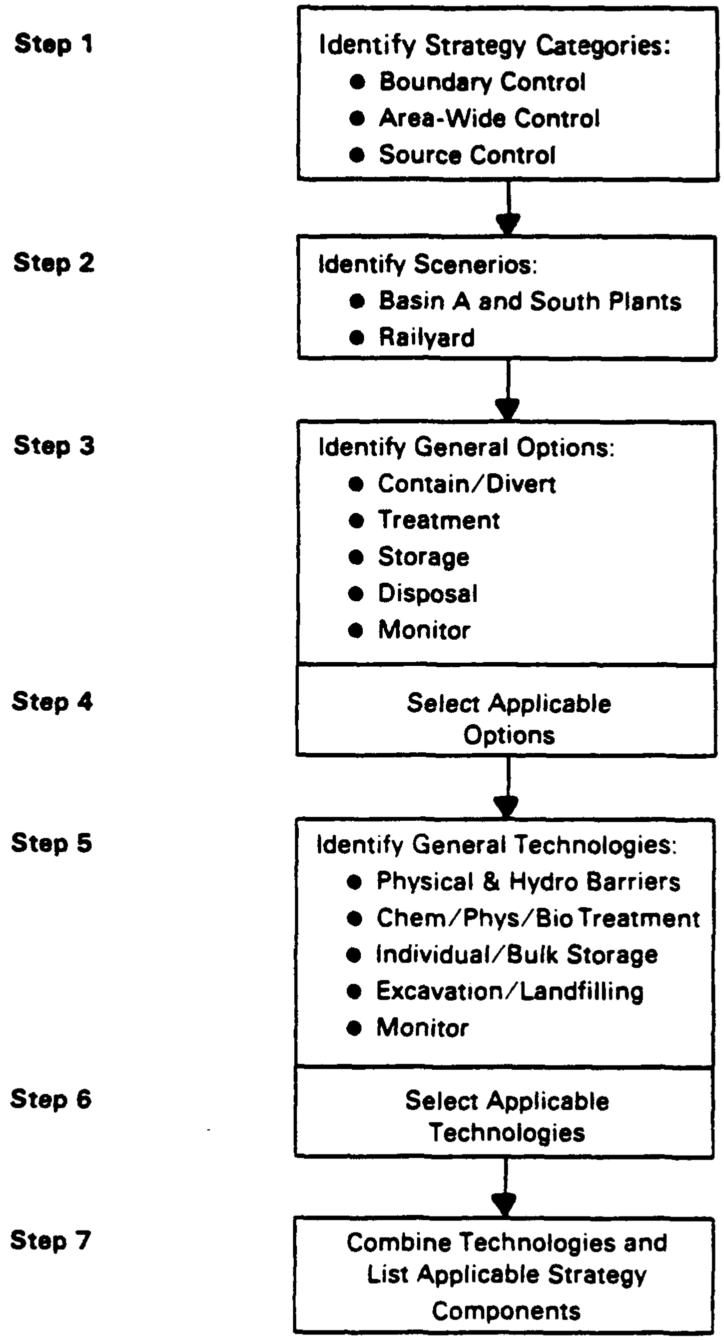


FIGURE 4-2
METHODOLOGY FOR DISCRETIONARY STRATEGY DEVELOPMENT

4.5 APPLICATION OF STRATEGY COMPONENT SELECTION METHODOLOGY FOR DISCRETIONARY ACTIONS AT BASIN A/SOUTH PLANTS AND THE RAIL CLASSIFICATION YARD

4.5.1 STEP 1 - Identification of Strategy Categories

4.5.1.1 Categorization of Strategies

The initial step in the formulation of the control strategies is the identification of viable control concepts. To ensure that as broad a range of strategies as possible was developed for evaluation, a set of categories was prepared with respect to approach or function. They are as follows:

a. Boundary Control

This concept entails the interception of the contaminated ground water flow at the property boundaries with either physical or hydrologic barriers, treatment and subsequent reinjection. The specific sources of the contamination are not addressed. Therefore, this control concept represents a collective removal of migrating contaminants at the "physical", and often interpreted, property boundary, regardless of their point of origin. The boundary control systems are long-term operations that must be maintained until such time as the contaminants from within the installation are flushed from the system. This action involves the leaching of the contaminants from the sources into the ground water and migration in association with ground water flow to the boundaries. At some point in time, with the elimination of disposal operations in the source areas, the contaminants will be leached to a concentration where dilution with upgradient "clean ground water" will result in a concentration of contaminants below associated regulatory criteria. This process is often long term and difficult to predict, based on typical geotechnical data bases.

b. Area-Wide Control

The concept of area-wide control concerns placement of control systems at locations interior to the property boundaries and sources, and/or control actions which act to prevent migration from more than one source area. Three conditions form the principal rationale for establishment of such a system. First, area-wide control systems may be a superior technique to eliminate migration of pollutants. Geotechnical conditions may be present to indicate there is a location between the source and property boundaries for optimal plume interception.

Also, in some locations individual source control may not be technically feasible or cost effective, due to the wide dispersion of activities over a large area of an installation. Second, area-wide schemes may yield significant cost savings by the interception of a more concentrated migrating plume nearer to the source, thereby reducing the total amount of waste water requiring treatment. Finally, if the long range goal is to release property, establishment of systems closer to the migration source would be beneficial to future land use planning.

c. Source Control

There are two subcategories of source control concepts that have been identified. These are source containment and source elimination.

(1) Containment

Containment involves physical control as near to the specific source as possible and serves to significantly reduce migration of contaminants. This system tends to intercept the contaminant migration pathways emanating from the source area, and, when used in combination with boundary control, serves to reduce the required operating life for all or part of the boundary control facilities. The boundary control systems would serve as a solution to the immediate problem of contaminant migration across the installation boundaries and to ensure that contamination, already present in the ground water system or released by the source containment system, would be prevented from exiting the Arsenal via the ground water system.

(2) Source Elimination

Source elimination, as a control concept, involves the removal and/or destruction of the contamination in a source area. This measure is a more permanent control than source containment. When considered for use in combination with boundary control, source elimination further reduces the required operating life of control facilities. In this case, the boundary control system would serve primarily as the solution to the immediate problem of contaminant migration across the installation boundaries, whereas source elimination is obviously designed to provide a long-term or ultimate solution.

These concepts, along with hybrids between the categories, provide a full range of strategies, from perpetual contamination control at the boundaries, to elimination of individual contaminant sources within the Arsenal.

4.5.1.2 Application to the RMA Program

All three categories of strategies could be technically applied to the RMA-IR Program. Boundary control has been successfully initiated at the RMA north and northwest boundary. With installation of a ground water control system at the northern portion of the northwest boundary, all off-post migration of contaminants will be stopped. The source areas determined to be out of compliance are remote from the boundaries, therefore, area-wide control between the source and the boundary may also be considered depending on geohydrologic conditions, cost and benefits. Source control for both containment and elimination of sources could be instituted at any of the source areas currently out of regulatory compliance.

4.5.2 STEP 2 - Identification of Scenarios

The hierarchical level of "scenario" requires the identification of specific source locations at RMA. The list of source areas, identified in Chapter 3 as out of regulatory compliance and requiring discretionary action, has been reduced to:

a. Basin A and South Plants.

b. Rail Classification Yard.

These areas will form the basis for strategy development throughout the remainder of this Chapter.

4.5.3 STEP 3 - Identify General Options

Several "options" were identified during the technical investigations for the development of control strategies.

4.5.3.1 Control (Containment/Diversion)

Control (containment/diversion) consists of physically controlling the migration pathways associated with a contaminant source or area. The resulting effect is that of isolating the contaminants from the migration mechanisms (surface water, ground water and wind).

4.5.3.2 Treatment

Treatment is any method, technique or process, including neutralization, designed to change the physical, chemical or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or as to render such waste nonhazardous or less hazardous; safe to transport, store, or dispose of; or amenable for recovery, for storage; or reduced in volume.

4.5.3.3 Storage

Storage is the holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere. This term signifies "temporary" handling of waste and, as such, is not a viable long term solution.

4.5.3.4 Disposal

Disposal is legally defined by RCRA as

> "the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or waters so that such solid waste or hazardous waste or constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground water."

This definition from the Federal Register covers all forms of disposal to include unintentional, intentional, and controlled. For the purposes of this report, disposal is hereinafter defined as controlled disposal.

4.5.3.5 Monitoring

Monitoring, in the context of this report, is the operation of Baseline and essential systems along with scheduled monitoring as a discretionary action. It provides a check to determine no change in source characterization will occur that will invalidate either Baseline or Basin F Closure operations.

4.5.4 STEP 4 - Selection of Applicable Options

4.5.4.1 Selection Criteria

The major criteria utilized for selection of applicable options are:

a. Regulatory Compliance

b. Compatability with Study Constraints and Assumptions

c. Technical Feasibility

d. Cost Effectiveness

4.5.4.2 Selection Process

The results of option level selection have been reduced to a matrix of "options" versus "scenarios" (source location) in Table 4-1. As seen from the table, only a portion of the possible option/scenario combinations were accepted for further evaluation.

Noted on Table 4-1 are the rejection criteria codes for each option/scenario. The following is an abbreviated discussion of each code and the rationale for rejection applied for each area.

a. Regulatorily Not Acceptable (RNA)

Regulatorily Not Acceptable (RNA) is based upon explanation of the State and Federal acts and regulations as they pertain to the RMA as discussed in Chapter 3.

b. Violates Constraints or Assumptions (VCA)

Violates Constraints or Assumptions (VCA) refers to the restriction of the Phase III as presented in Section 1.5 of Chapter 1.

c. Technically Not Feasible (TNF)

Technically Not Feasible (TNF) is used to reject options that would require tecnnology not fully developed to be applied to current problems or the actual development of technology. Time is also a consideration since the technology required must support the implementation of projects by FY88.

TABLE 4-1
OPTION LEVEL SELECTION MATRIX
FOR DISCRETIONARY ACTIONS

SCENARIO/ SOURCE LOCATION	OPTIONS				
	CONTROL	TREAT	STORE	DISPOSE	MONITOR
Basin A and South Plants					
Surface Water/Sediments	X	X	RNA	RNA	RNA
Ground Water	X	X	RNA	RNA	X
Soils	X	CP & VCA & TNF	RNA	CP & TNF & VCA	X
Rail Classification Yard					
Ground Water	X	X	RNA	RNA	X
Soils	TNF	VCA & TNF	RNA	X	X

Note: Acceptance Code
X = Applicable

Rejection Codes/Criteria
RNA = Regulatorily Not Acceptable
VCA = Violates Constraints or Assumption
TNF = Technically Not Applicable
CP = Cost Prohibitive

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d. Cost Prohibitive (CP)

Cost Prohibitive (CP) is used to reject options that require a large handling of material and/or require the utilization of technology that is expensive and complex.

4.5.4.3 Selection Rationale

The options for each scenario are described as follows:

a. Control

Control of liquids is an acceptable option. For soils, the control option is limited to preventing windblown movement since soil is a non-mobile medium. In all cases this is an acceptable option; however, the Rail Classification Yard does not exhibit a tendency for wind transport and as such this option serves no purpose and is rejected as TNF.

b. Treatment

Treatment of surface/sediments and ground water in all cases is a feasible option and is considered acceptable. The treatment of soils lacks the engineering experience that is available for water. As such, the program would have to be initiated to determine not only the extent of soil to be treated, but also an engineering study to define the appropriate and feasible methods. Because of the constraint on time, regulatory acceptance and technology, the treatment of soils is considered VCA and TNF. In addition, the volume estimate for Basin A and South Plants Area are as high as 12 million cubic yards and as such is also considered CP[12].

c. Storing

Storing of materials is defined as a temporary measure and as such is considered RNA as a method of long-term compliance.

d. Disposal

Disposal of liquids without removal of the contaminants is prohibited by RCRA (Chapter 3) as well as NPDES, which regulates surface water discharges. Because of the restrictions imposed by these regulations, all water disposal is rejected as an option as RNA. The option to dispose of soils in a controlled landfill is a viable option and should be considered. The only rejection occurs in the Basin A and South Plants area, which would require the disposition of approximately 12 million cubic yards of contaminated soils above the water table. Additionally,

numerous buildings would have to be razed. No estimate is currently available for volumes of contaminated soil below the water table. Based upon this information, the disposal of the Basin A and South Plants soils is considered CP, TNF and VCA.

e. Monitoring

Monitoring of the media in the areas of concern as the option of choice is viable in some situations. For the ground water of the Basin A and South Plants and Rail Classification Yard, the option is possible, since the contamination known to be moving is caught and treated at the boundary control systems. Similarly, the soil in these areas could be monitored to detect physical movement and estimate the extent of land area affected. Surface water flows in the South Plants are suspected of being contaminated and must be controlled.

4.5.5 STEP 5 - Identification of General Technologies

4.5.5.1 Available Technologies

There are a considerable number of technologies available to stop contaminant release to the environment within each "option" level. These technologies cover a wide range of alternatives and represent varying degrees of complexity. To generate a comprehensive list, definitions of response actions were compiled from various environmental regulations applicable to RMA. The following technology categories are considered applicable to conditions at the Arsenal.

a. Control

- Physical Barrier
- Hydrological Barrier
- Capping

b. Treatment

- Chemical
- Physical
- Biological

c. Disposal

- Excavation, transportation and landfilling (secure)
- Deep well injection

d. Monitoring

In order to understand the application of these technologies to the individual scenarios, a description of each is required. The following sections provide a description of each technology and to which media it can be applied.

4.5.5.2 Control Technologies

a. Physical

Physical barrier control is considered to be the placement of a fixed barrier in a manner such that it diverts or contains the movement of water and sediments. This technology includes the use of items such as slurry walls, sheet pile, grout curtains, diversion structures, dams, ditches, etc. Because of its nature, this type of control is not applicable to soils.

b. Hydrological

Hydrological barrier control is defined as the removal of water through pumping to divert water so as to create an artificial barrier, dewater a surface flow or reduce mounded water. This technology is not applicable for soils.

c. Capping

Capping as a control is the physical covering of a land mass so as to eliminate or reduce the infiltration of water into the ground or movement of wind blown material. This technology is applicable to soils and ground water since it will influence infiltration to the water table and reduce dust movement.

4.5.5.3 Treatment Technologies

a. Chemical

Chemical treatment is the addition of various select chemicals to water or soil so as to oxidize, reduce, neutralize, or react with the contaminants present. Techniques in this category include UV/ozone, chemical addition, incinerations etc.

b. Physical

Physical treatment is defined as a material process that removes the contaminants without a chemical reaction or change of the contaminant. Processes of this type include filtration, adsorption, stabilization, stripping, etc. This technology is applicable to soil and water.

c. Biological

Biological treatment utilizes bacteria under aerobic or anaerobic conditions to degrade chemically harmful substances into innocuous compounds.

4.5.5.4 Disposal Technologies

a. Excavation, Transport and Landfilling

Excavation, transport and landfilling is the physical removal of solid material from its present location and the landfilling in a secure site either in place, on RMA or off-post. Because of the prohibition of landfilling liquids, only solid materials will be considered in utilizing this technology.

b. Deep Well Injection

Deep well injection is a technique for the disposal of liquids several thousand feet into deep stratigraphic formations. This technique is not applicable to solid materials.

4.5.5.5 Monitoring

This action is a continuing check of the status of the selected areas and medium in the event no corrective action is taken. This will allow RMA to maintain an active status review of each site.

4.5.6 STEP 6 - Selection of Applicable Technologies

4.5.6.1 Rationale for Acceptance/Rejection of Technologies

The screening of various stategies at the "technology" level was carried out in a similar manner as that done at the "option" level. Table 4-2 presents the results of the technology assessment. The following discussion presents the rationale for accepting or rejecting technologies for each of the "scenarios" identified. The technical information used was obtained from engineering studies conducted through FY82.

a. Control via Physical Barrier

Control via physical barrier as defined in section 4.5.5 does not apply to soils and therefore, is considered only for surface and ground water for the Basin A/South Plants and the Rail Classification Yard. Diversion and/or damming are acceptable

TABLE 4-2
TECHNOLOGY LEVEL SELECTION MATRIX
FOR DISCRETIONARY ACTIONS

SCENERIO/ SOURCE LOCATION	TECHNOLOGIES								
	CONTROL			TREAT			DISPOSE		MONITOR
	Physical Barrier	Hydrologic Barrier	Capping	Chemical Treatment	Physical Treatment	Biological Treatment	Excavate Transport and Landfill	Deep Well	
Basin A and South Plants									
Surface Water/ Sediments	A	A	A	A	A	R	—	—	—
Ground Water	A	A	A	A	A	R	—	—	A
Soils	*	*	A	—	—	—	—	—	A
Railyard									
Ground Water	R	A	R	R	A	R	—	—	A
Soils	—	—	—	—	—	—	A	R	A

Note: A = Accept
R = Reject
— = Eliminated at Option Level
* = Technology Not Applicable

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technologies for control of surface water and sediments from the Basin A/South Plants region. Of the physical barrier techniques available to contain ground water, only the soil/bentonite slurry trench has been found to be feasible at RMA. Previous investigations at the North Boundary, as part of pilot system design, encountered feasibility difficulties with concepts such as sheet pile and grout curtains. However, slurry trenches are not a panacea. To use a slurry trench many conditions have to be met. First, the slurry wall must remain relatively impermeable when contacted by the contained waste. Next, geologic and geohydrologic conditions must allow the trench to be anchored into impermeable strata. Last, placement difficulties and cost are directly related to the depth of trench excavation. For depths up to 50 feet a backhoe can be used. Depths of 50 -150 feet require use of a clamshell. State-of-the-art techniques are required beyond 150 feet. In the Basin A and South Plants Area, the depth to bedrock are around 30 - 50 feet, and therefore a slurry wall could be utilized in controlling ground water flow from Basin A or preventing ground water from entering or exiting the South Plants Area. In the Rail Classification Yard, the depth to bedrock approximates 110 feet. Engineering studies by Shell Chemical Company for the Irondale containment system, located in a similar geohydrologic setting, indicated that a hydrologic system would be more cost effective. For this reason a slurry wall is rejected as a technology for the Railyard.

b. <u>Control via Hydrologic Barriers</u>

Control via hydrologic barriers utilizes the removal or transfer water to achieve containment and is therefore not applicable for soils. Surface water in the Basin A/South Plants has occassionally been found to contain pollutants which presumably originate from surface source of contaminants. Dewatering of the surface outfalls could remedy this situation and thus has been accepted as an applicable technology. An artificial ground water mound exists beneath the South Plants Area due to leaking pipes and sewers. Lowering of the mound expeditiously will aid in control of the movement of contáminated ground water from the area. Dewatering of the mound via a series of low capacity wells has been determined to be feasible to minimize the future spread of pollutants to aquifer areas now clean.

Ground water control at the Rail Classification Yard would be beneficial in capturing contaminants at their source and allowing early decommission of the Irondale boundary control system which employs a hydrological system to stop the migration of DBCP. The system works on the principle of water table gradient reversal by lowering the aquifer along an extraction well line and building up the aquifer along a recharge well

line. The same principle can be applied nearer to a surface source by removing only the ground water at the top of the aquifer when the contaminants are stratified. This technique has been accepted as a viable technology for the Rail Classification Yard.

c. Control via Capping

Control via capping is an effective means to control infiltration of surface water and mitigate dust movement. Due to the need for surface contouring and placement of an impermeable layer, this technique is not directly implementable at the Rail Classification Yard or within the South Plants Area. These areas are currently in use and existing surface structures preclude deployment of capping technology by FY88. The Basin A area could be capped for control of percolation, surface runoff and further dust movement (the baseline includes windblown dust control). Capping of the dry basin would likely improve downstream ground water quality by preventing percolating water from mobilizing contaminants in the unsaturated zone.

d. Chemical Treatment

Chemical treatment has been studied for various surface and ground waters on RMA. Its use has been demonstrated: (1) as a pretreatment stage to remove heavy metals, and (2) as a primary treatment stage (eg UV-Ozone) for complex organic wastewaters. Both surface water and ground water in the Basin A/South Plants Area contain high levels of heavy metals and numerous organic compounds and, therefore, chemical treatment has been accepted for these areas. Treatment of ground water from the Rail Classification Yard will not need any of the above mentioned demonstrated capabilities since the only compound requiring removal has been successfully treated via physical means.

e. Physical Treatment

Physical treatment of surface and ground water has been found feasible and cost effective at RMA. Techniques such as stripping of volatiles, filtration of solids and adsorption of a variety of pollutants on carbon or alumina have been tested on water from the North Boundary, Basin F, Basin A and South Plants Areas. Depending on the type of pollutant found within the water of concern, any of these techniques could be used and therefore this technology has been accepted.

f. Biological Treatment

Biological treatment of contaminated water has been investigated only in a preliminary fashion. Shell Chemical Company suggests its incorporation in the treatment of solvent laden ground water

in the South Plants[13]. However, independent study early in the RMA Contamination Control Program indicated that biological treatment fails to reduce selected pollutants to the required levels while at the same time creating breakdown products that may be more toxic than the original constituents themselves. Because of these problems and the lack of time to demonstrate the process feasibility, this technology has been rejected.

g. Excavation, Transport and Landfill

Excavation, transport and landfill is applicable to the soils in the Railyard. Disposal site of this contaminated material will be the same as that for Basin F (e.g., insitu at Basin F, onsite at RMA or offsite).

h. Deep Well Disposal

Deep well disposal is applicable only to liquids; however, this method of disposal has proved to be unacceptable at RMA. Past deep well disposal of Basin F liquids in the early 1960's resulted in operational fouling difficulties and may have contributed to increased seismic activity in the Denver vicinity. Therefore, this technology has been rejected.

i. Monitoring

Monitoring for Basin A, South Plants Area, and the Railyard is considered a viable technology. Baseline and essential actions will result in controlling all avenues of contaminant movement off-post; boundary control systems will stop contaminated ground water flow off RMA, Basin A windblown dust control will mitigate contaminated particulate movement, Lower Lake sediment removal will reduce wildlife contact with pollutants in the lake bottom and Basin F closure will eliminate volatile emissions and wildlife contact from remaining liquid impoundment. A "wait and see" posture is therefore realistic for the discretionary source areas.

4.5.6.2 Screening Results

The discretionary "technologies" found applicable to sites at RMA are summarized in Table 4-3. From the list it can be seen that many common approaches emerge. In general control/treatment of waters at RMA entail some sort of containment followed by physical treatment. Chemical treatment is required as one approaches the complex source area of Basin A and the South Plants Area. This technology is similar to that already employed at the Arsenal boundaries. Control of pollutants in soils prior to migration, involves either capping at select sites or soil removal to an approved disposal site.

TABLE 4-3
APPLICABLE TECHNOLOGIES FOR DISCRETIONARY SOURCES

SCENARIO/SOURCE LOCATION	GENERAL TECHNOLOGY	APPLICATION OF SPECIFIC TECHNOLOGIES
Basin A and South Plants:		
Surface Water & Ground Water	Physical Barrier	Bentonite Barrier, Ditching, Containment
	Hydrologic Barrier	Pump Mound
	Capping	Basin A Only
	Chemical Treatment	Chemical Addition, Pretreatment, and Primary Treatment Via Uv/Ozone
	Physical Treatment	Filtration, Carbon Adsorption, and Stripping
	Monitoring	Ground Water Only
Soils	Monitor	Windblown and Surface
Railyard:		
Ground Water	Hydrologic Control	Hydrologic Barrier Controlling Top of Aquifer Only
	Physical Treatment	Carbon Adsorption
	Monitor	Ground Water
Soils	Excavate Transport and Landfill	Must Consider In-Situ, on RMA and off RMA
	Monitor	Wildblown and Surface

4.5.7 STEP 7 - Combine Technologies and List Applicable Strategy Components

The objective of any positive action at Basin A and South Plants Area is to eliminate contaminant migration toward the RMA boundaries. In order to effect this goal, water exiting the Basin A area must be controlled. The method of choice among the technologies in Table 4-3 is a physical barrier* located at the Basin A "neck" area. In conjunction with this, the water stopped must be removed and treated either chemically and/or physically before reinjection into the aquifer. In the Basin A area, capping alone or in conjunction with a barrier must also be considered to reduce movement of contaminants into the ground water.

The South Plants Area is a source of a large variety of chemicals. The options available in Table 4-3 are to hydrologically control and treat the ground water and to physically block water entering or exiting the southern end of the area. By hydrologically controlling the area, the artificial mound will be reduced, thereby significantly decreasing the current radial driving force moving pollutants out of the area. The mound reduction will allow a small but continued influx of clean water from the south to backwash any ground contamination. This concept will have to be operated continually to remove chemicals from the area.

The South Plants Area dewatering and treatment with a barrier will provide added insurance that contaminated water in the area will not exit to the south into a large aquifer system. This system will also provide a reduced operation of dewatering of the South Plants Area by reducing any area water infiltrating from south of the area. The Lower Lakes operation will not affect the area because of the physical barrier preventing influx.

The last primary site is the Rail Classification Yard. The strategy components of choice are to leave the site as is, monitor the spill area and allow the DBCP to be caught and treated at the Irondale system. Another is to develop a hydrologic control and physical treatment at the site of the spill. A third is to physically remove the soil in the area of the spill and move it to a landfill.

4.6 SUMMARY OF CONTROL STRATEGY COMPONENT SELECTION

Selection of feasible control strategy components for those source areas determined to be out of compliance in Chapter 3 was accomplished through the evaluation of technical, cost and regulatory data developed as part of the Contamination Control Program for RMA. Table 4-4 summarizes these strategies, noting whether the action is essential or discretionary. A plan view is presented at this point for each of the resulting strategy components (less monitoring) providing a perspective of system location, size and orientation. Each of the strategies will be addressed in detail in Chapter 5 to determine the optimum corrective alternative for each site.

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*Note: The use of the term "physical barrier" for the Basin A "Neck" region does not preclude consideration of either a hydrologic or bentonite slurry wall in the final design.

TABLE 4-4
STRATEGY COMPONENT SUMMARY

SOURCE AREA	RESPONSE ACTION CATEGORY	STRATEGY COMPONENTS
Basin F	Essential	a) Excavate, Solidify and Landfill In-Situ b) Excavate, Solidify, Transport and Landfill in a RCRA disoposal site on-site c) Excavate, Solidify, Transport and Landfill in a RCRA disposal site off-post
Basin A and South Plants	Discretionary	a) Physical Barrier at A "Neck" with Chemical and Physical Treatment b) Cap Basin A c) Combination of a) and b) d) Monitor Soil and Water in Basin A e) Dewater the mound in South Plants with Chemical and Physical Treatment f) Physical Barrier plus e) g) Surface Water Management h) Monitor Water in South Plants
Rail Classification Yard	Discretionary	a) Hydrologic Barrier with Physical Treatment b) Excavate, Transport and Landfill to RCRA Landfill c) Monitor Ground Water

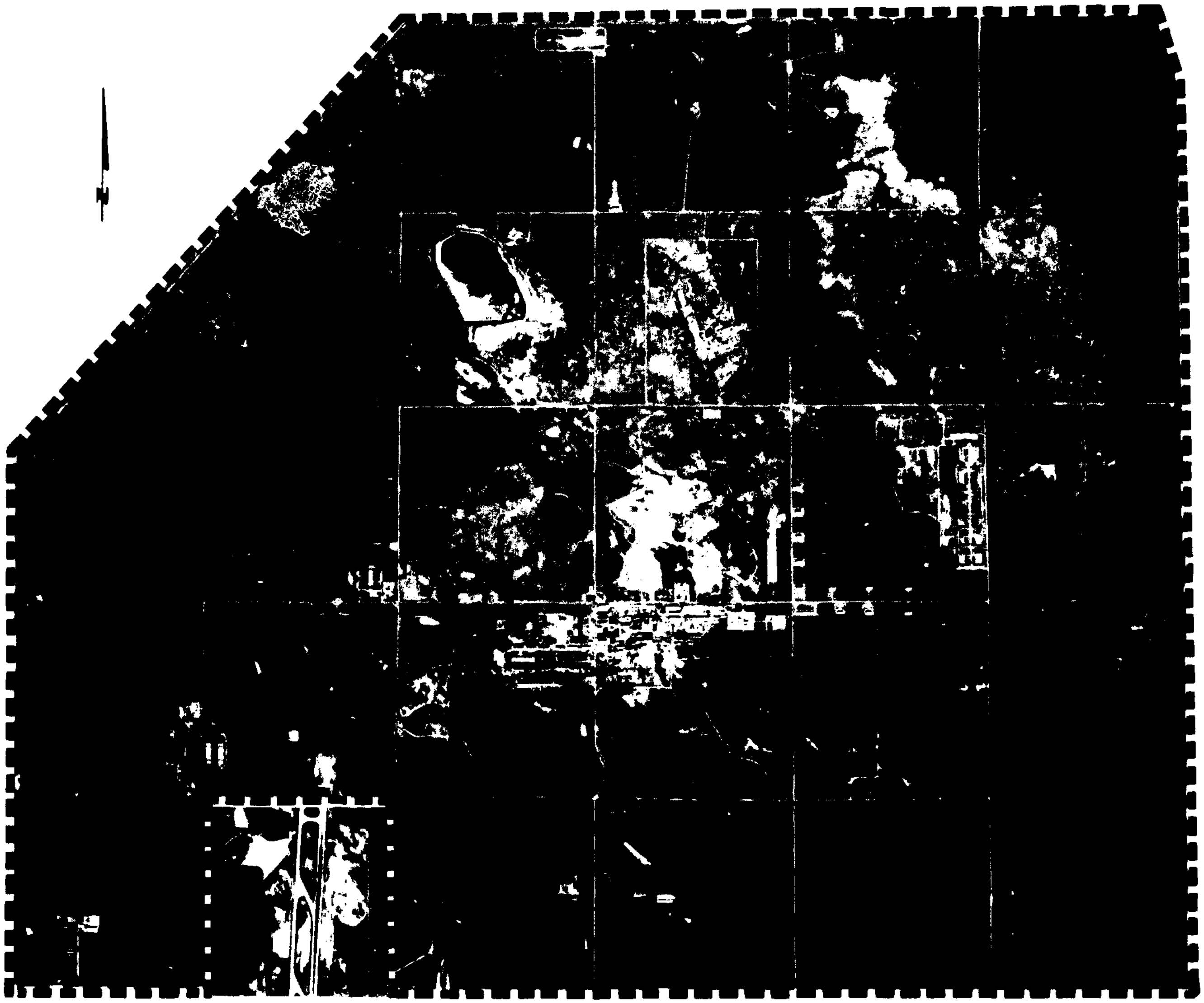


FIGURE 4-3
IN SITU CLOSURE BASIN F

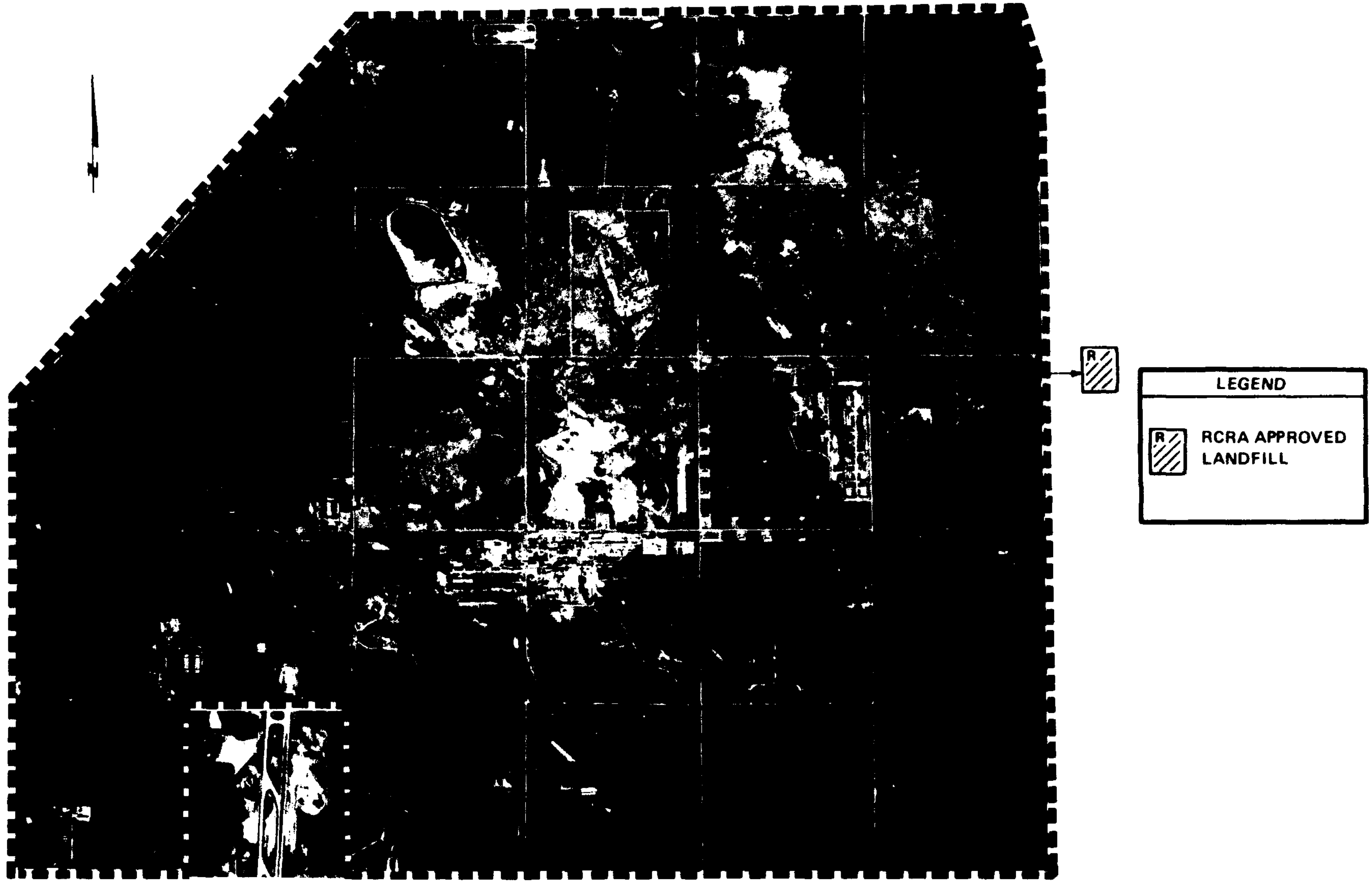


FIGURE 4-4
REMOVE AND DISPOSE BASIN F
IN RCRA LANDFILL

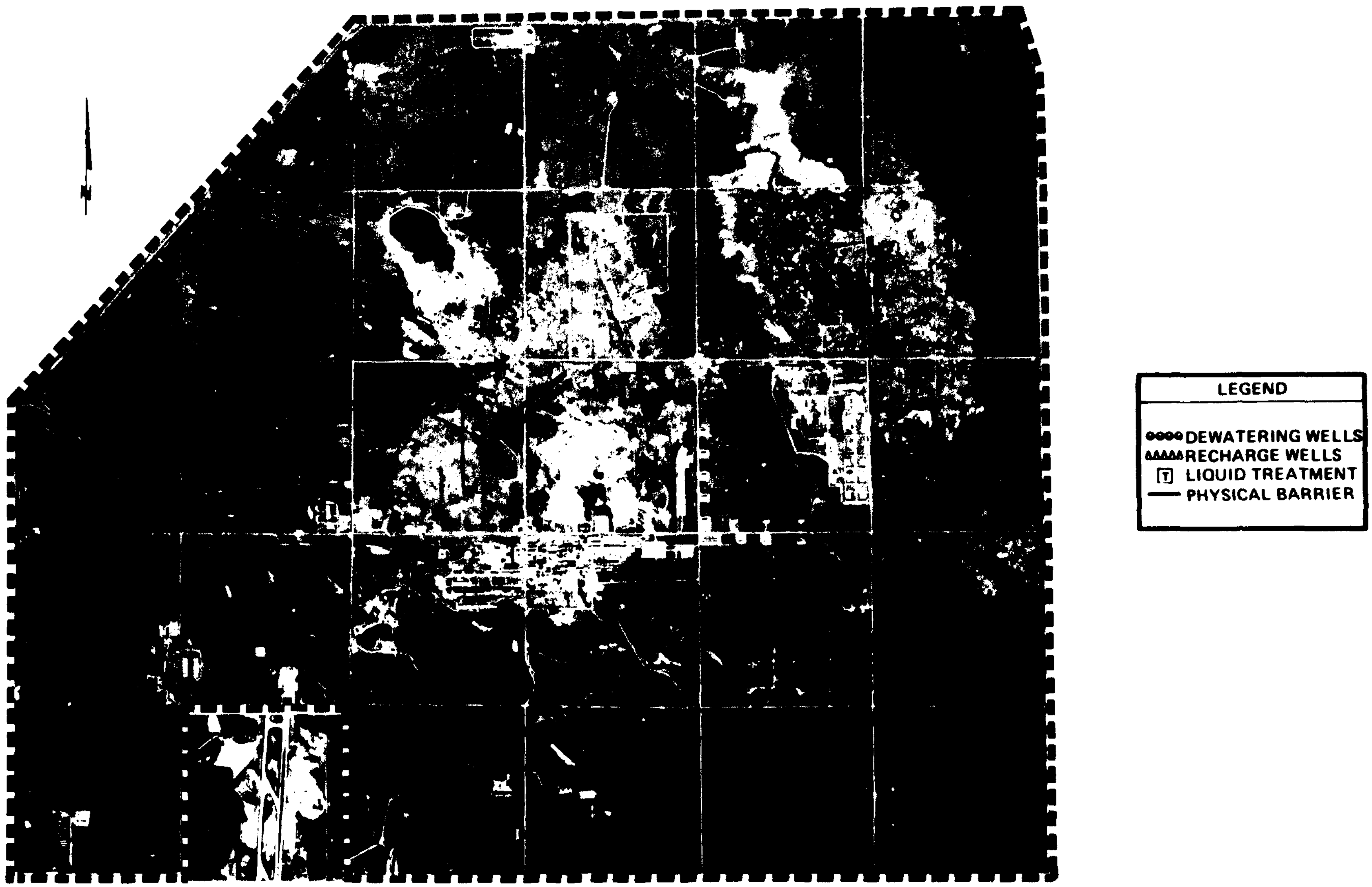


FIGURE 4-5
A NECK CONTAINMENT AND
TREATMENT SYSTEM

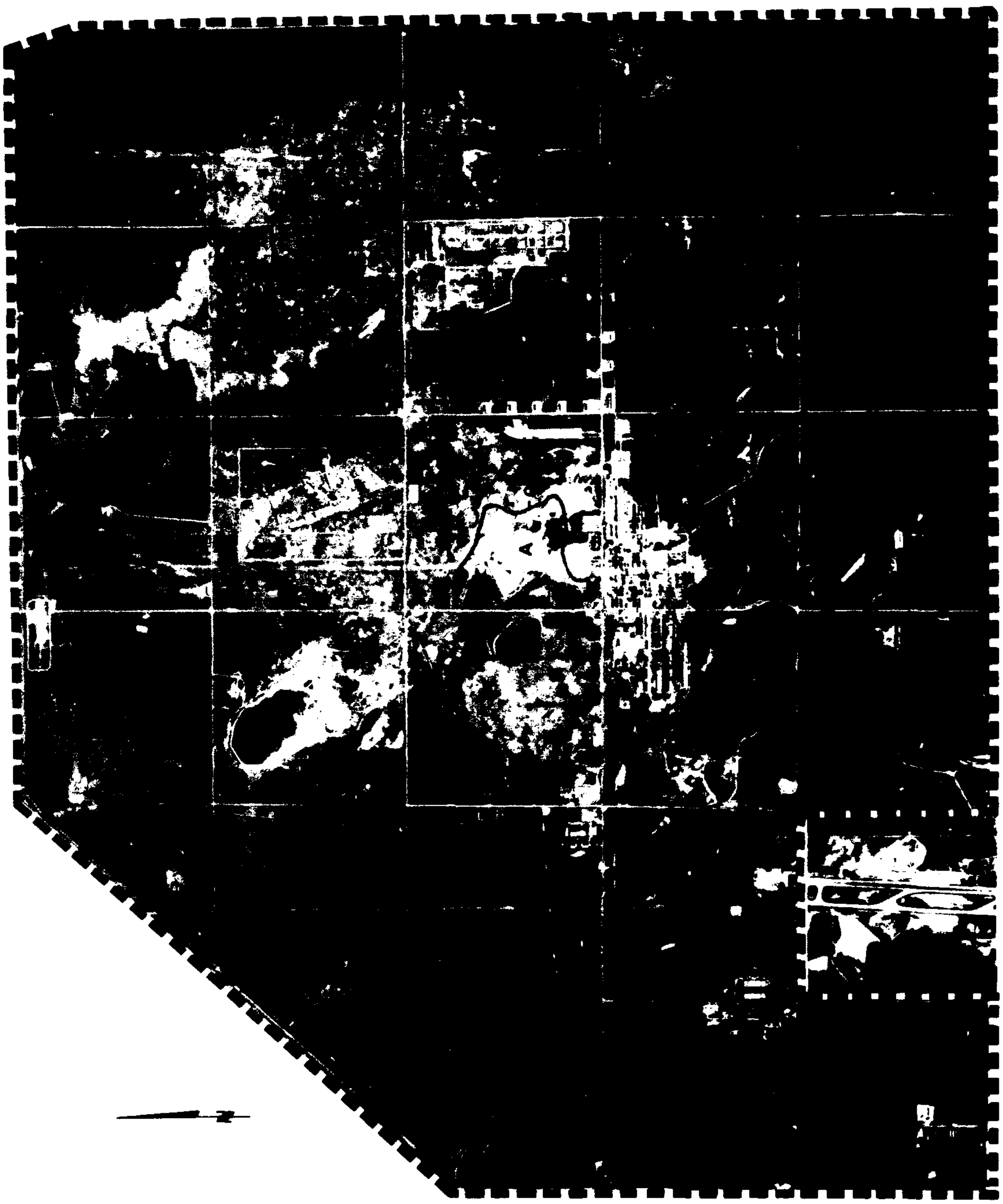


FIGURE 4-6
BASIN A CAP

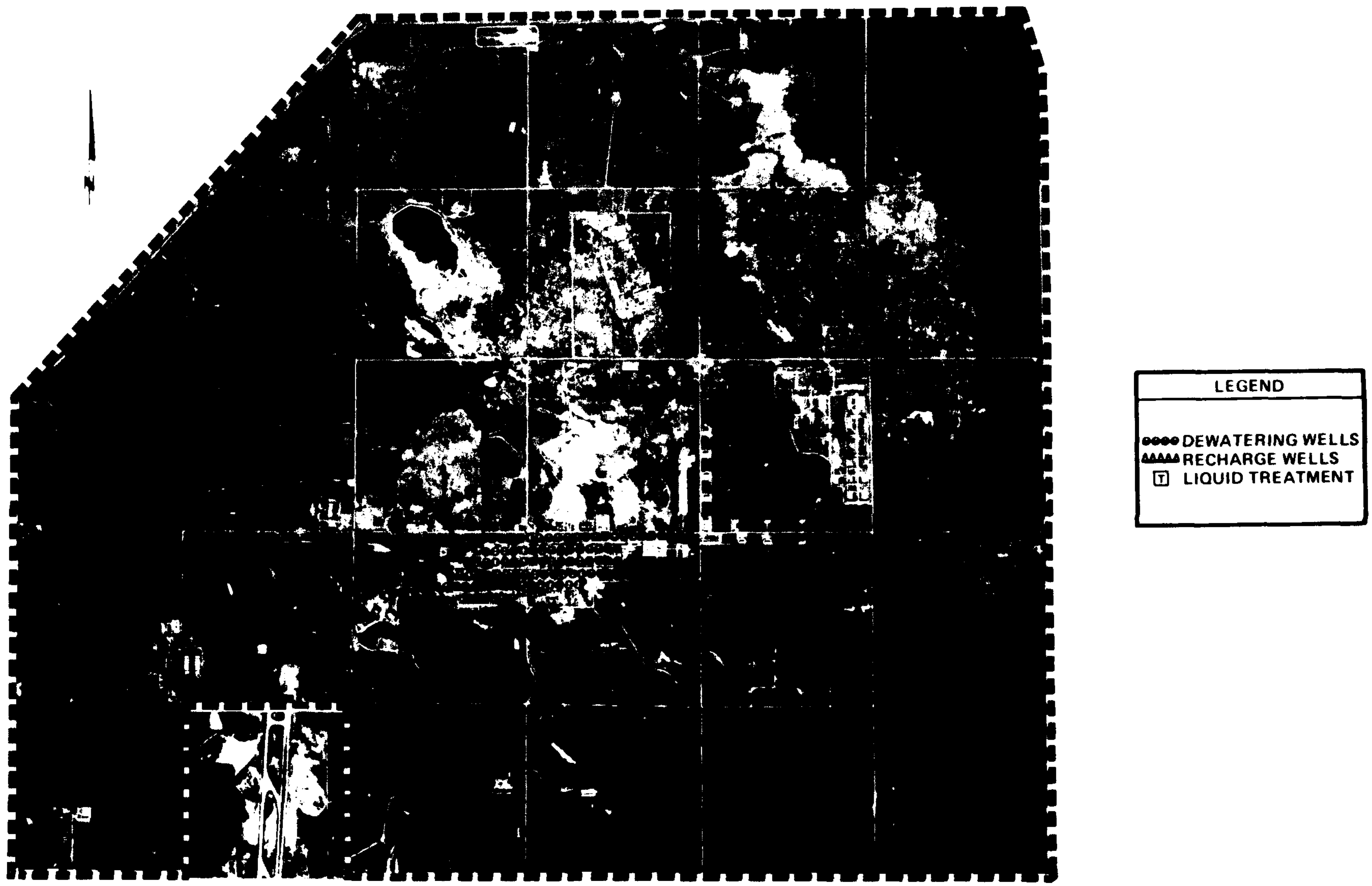


FIGURE 4-7
S. PLANTS DEWATERING
AND TREATMENT

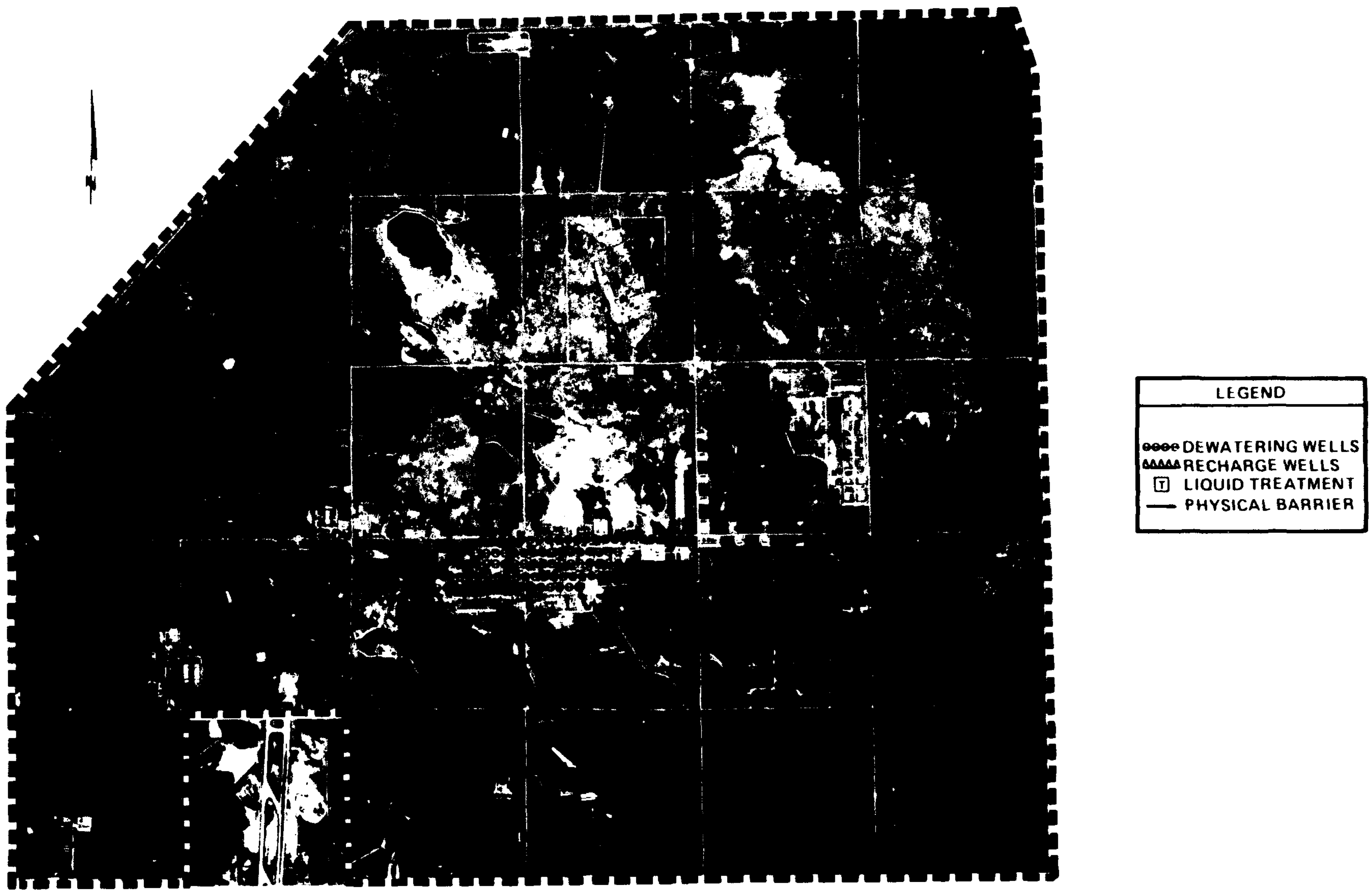


FIGURE 4-8
S. PLANTS DEWATER AND TREATMENT
WITH BARRIER

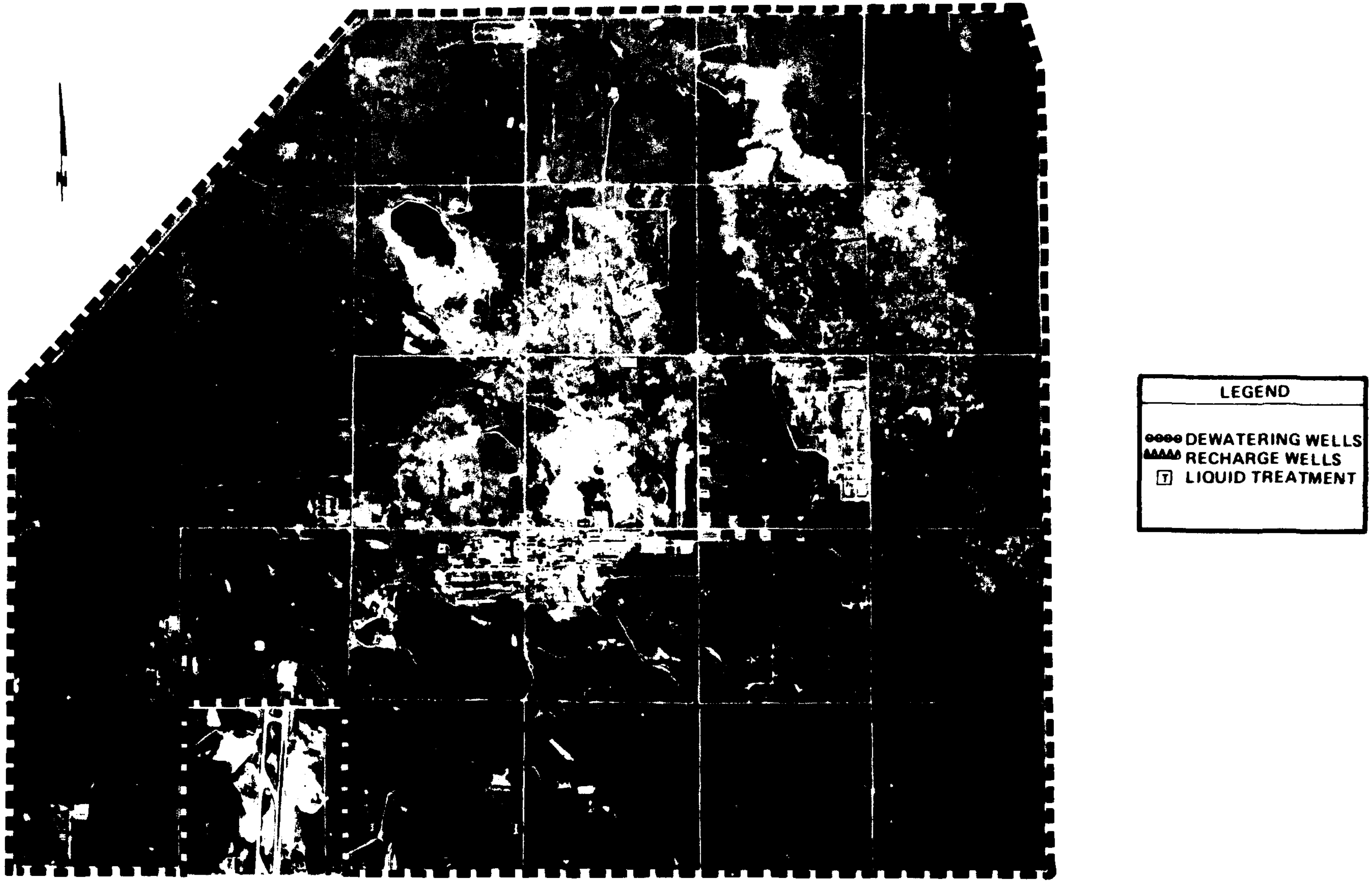
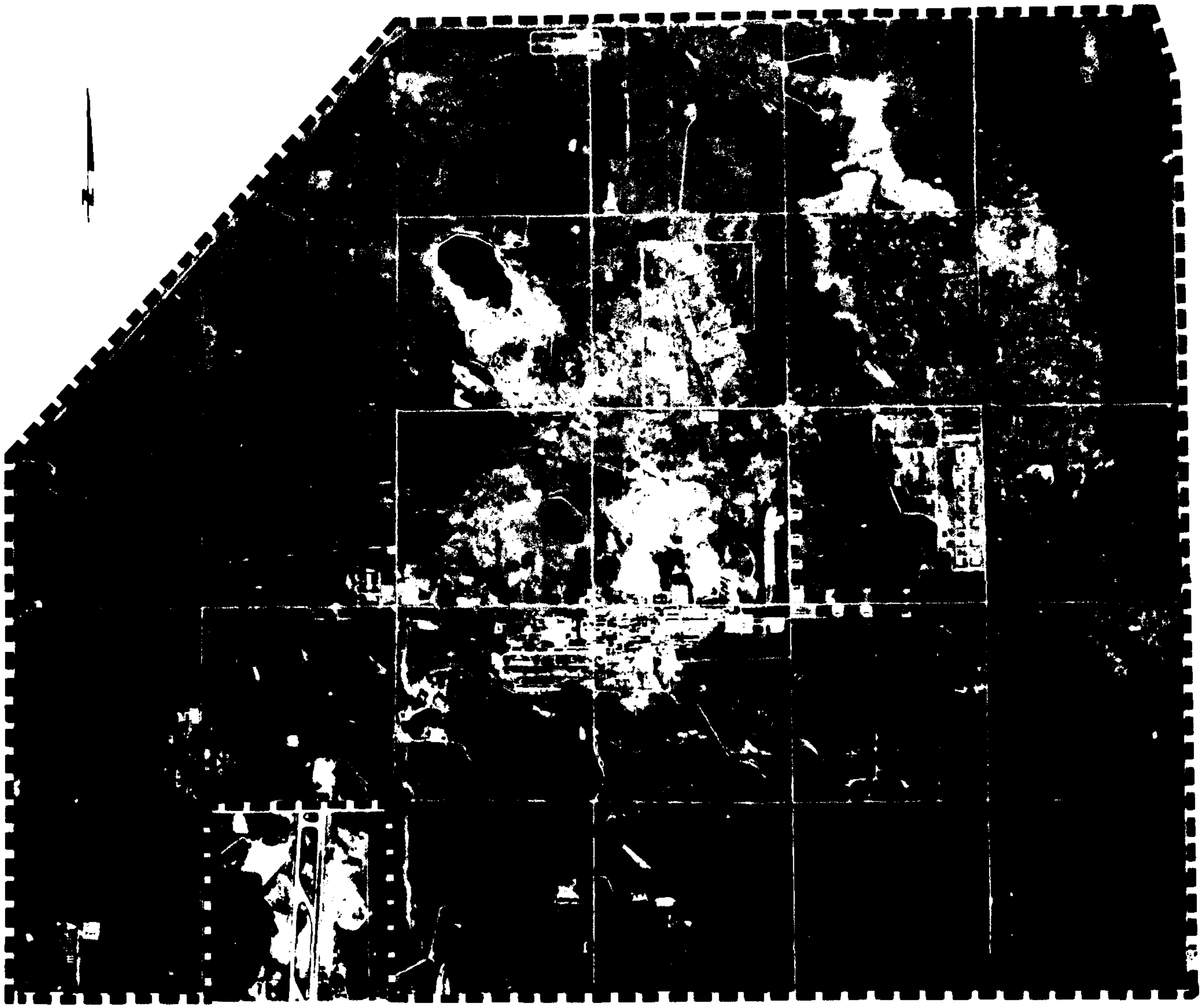


FIGURE 4-9
RAIL CLASSIFICATION YARD
CONTAINMENT AND TREATMENT



NOTE:

DISPOSAL OF
CONTAMINATED SOILS
WILL BE AT
THE SAME LOCATION
AS BASIN F
WASTES.

FIGURE 4-10
RAIL CLASSIFICATION YARD
SOIL REMOVAL

CHAPTER 5
SELECTION OF OPTIMUM CONTROL STRATEGY COMPONENTS

5.1 INTRODUCTION

Chapters 2 through 4 of this report have provided an understanding of the environmental setting of RMA, assessed applicable environmental regulations pertinent to contamination control activities at the Arsenal, and developed response actions for each source area of concern. This Chapter will analyze each of the response actions listed in Table 4-4 to select the optimal strategy components. The following sections describe the analysis methodology and summarize the rationale used to select the preferred contamination control alternatives.

5.2 OVERVIEW OF SELECTION METHODOLOGY

A conventional cost/benefit/risk analysis technique has been chosen for use within this study. Selection of a control strategy will be based on the lowest cost alternative which adequately protects public health, welfare, or the environment and which presents acceptable technological risks.

a. Cost will be developed in quantifiable terms and broken down into capital (construction), operations and maintenance, and replacement elements. A present worth cost comparison, prescribed by Army regulations, will translate these costs elements into a common base year, 1982, for evaluation purposes. Cost savings resulting from early termination of baseline boundary operations will be considered whenever applicable.

b. Benefits will be analyzed in qualitative terms as they relate to positive environmental impacts. Regulatory acceptability and time to implement will be the principal elements to be considered.

c. Risk will also be analyzed in qualitative terms as it relates to the technical elements of availability of proven technology, availability of data, system compatability and Army liability.

Computer model simulation of ground water flow in and around RMA was performed to evaluate the hydraulic interaction of the proposed control strategy components[14]. The modeling demonstrated that most source areas can be analyzed independent of one another. Hydrogeologic effects of the major systems in Table 4-4 are expected to be on a local scale in the immediate area of the source. The source areas in which interaction is expected will be Basin A and the

South Plants. Within this region, one must examine the strategy components in conjunction with one another to arrive at an optimal control strategy.

Once the subset of optimal strategy components are selected, an assembly of these will be made to assure overall optimization. Chapter 6 will further evaluate the overall strategy to examine possible cost savings and technical advantages of combining like components.

5.3 STRATEGY COMPONENT SELECTION FOR ESSENTIAL ACTIONS AT BASIN F

5.3.1 Description of Components

The components found applicable in Chapter 4 to closure of Basin F under RCRA are described below.

5.3.1.1 Excavate, Solidify and Landfill - In Situ

This concept utilizes a portion of the existing Basin F site as a repository for hazardous material removed from the surface impoundment. The liquid/sludge portion of the Basin will be dredged and stabilized with a silica based solidifying agent. This material would then be transported to a temporary holding facility. Simultaneously, the overburden and liner will be excavated and mixed with kiln dust to ensure stabilization of any residual liquids. The contaminated soil from beneath approximately 40 acres of the Basin, along with the solidified wastes above, would be placed into the north end of Basin F. A cover of topsoil, clay and a synthetic membrane would be placed over the final 53 acre site to prevent infiltration of surface water. Monitoring of the site would be conducted quarterly to check that no leachate is produced that would recontaminate the aquifer beneath Basin F.

5.3.1.2 Excavate, Solidify, Transport and Landfill - RCRA Disposal On-Site

This concept is similar to the in situ concept except that all the hazardous wastes would be physically treated and transported to an approved RCRA disposal site on RMA. The on-site facility would be permitted, constructed and operated at a suitable site within the Arsenal thereby eliminating packaging and manifest requirements. For illustrative purposes, a conceptual drawing of a typical "hazardous waste landfill cell" is presented in Figure 5-1. As envisioned, the on-site disposal facility would consist of a number of modular cells that would be filled and closed using a phased approach. This

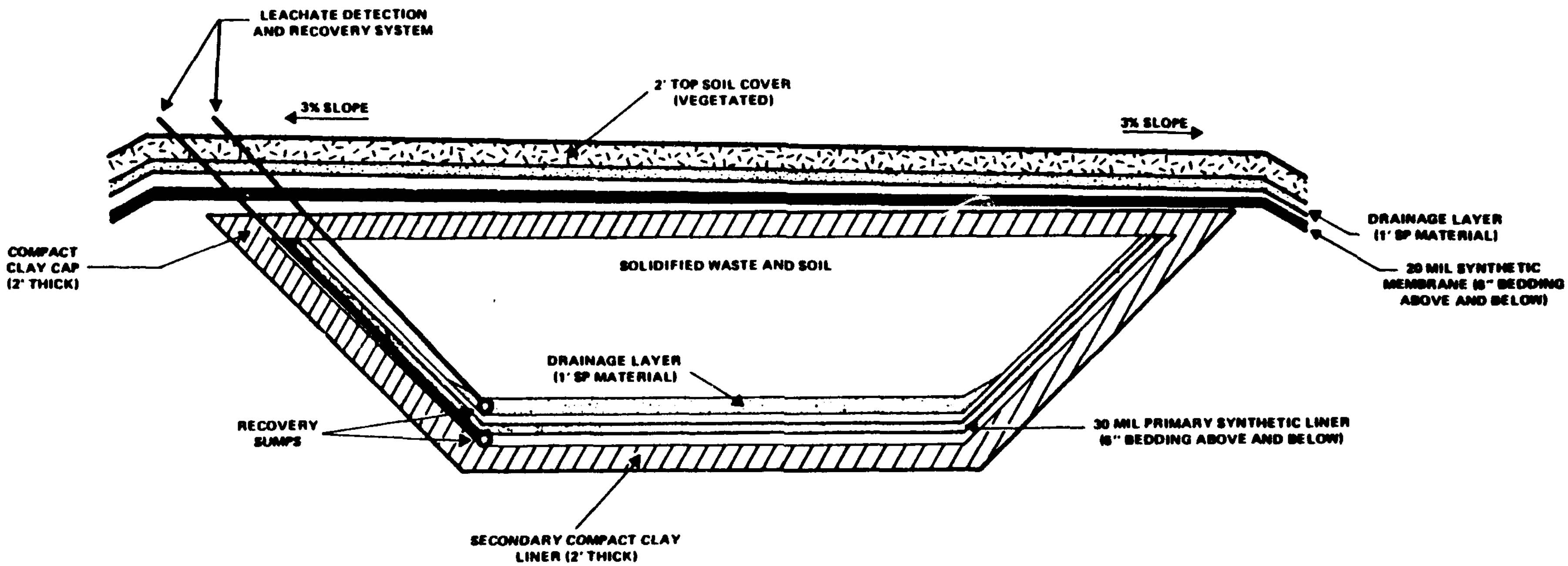


FIGURE 5-1
CONCEPTUAL RCRA LANDFILL DISPOSAL CELL CROSS-SECTION

operation would be continuous until Basin F waste excavation was completed. If delays were encountered due to weather or mechanical breakdown, a temporary cover would be placed on the waste material in the cell to prevent waste material saturation, fugitive dust and/or wildlife contact with the hazardous constitutents. After completion of the landfill activities in a particular cell, the unit would be closed in accordance with RCRA/State regulations by placement of an impermeable cover over the cell consisting of topsoil, clay and an impermeable membrane. The old Basin F site will be closed by pushing the remaining dikes into the basin and by placement of a clay/topsoil cover over the entire 93 acre site. Current regulations require monitoring of the new landfill site for a period of thirty years after closure.

5.3.1.3 Excavate, Solidify, Transport and Landfill RCRA Disposal Off-Site

This concept is identical to on-site disposal except that the landfill utilitized would be a commercial or privately-owned off-site establishment. The use of an off-site disposal facility would involve (1) collection and packaging of the waste material to meet Department of Transportation requirements, (2) preparation of a manifest, and (3) transportation of the packaged waste to the landfill by a licensed transporter. The operator of the landfill would then dispose of the waste at a prearranged disposal fee. Off-site disposal would be complicated and relatively expensive. There are no operational, permitted disposal facilities in the Colorado region capable of handling Basin F wastes. As a result the closest facilities are located in Idaho and Texas. Furthermore, the extremely hazardous and corrosive nature of the Basin F liquid combined with the potential for a spill to occur during transportation and handling of the large volume of material (12.5 million gallons) would require that the liquid be solidified prior to transportation. Solidification, however, increases the volume and the cost dramatically.

5.3.2 Cost

Capital, operation and maintenance, replacement and present worth costs for the three Basin F components have been developed (see Appendix E) and are presented in Table 5-1. Transportation and waste placement costs for the off-site landfill are based on current information. The closest existing RCRA landfill is 800 miles from RMA. No consideration was given to possible future landfills in Colorado, since permitting of new sites has been repeatedly turned down by approving officials.

TABLE 5-1
COSTS FOR BASIN F STRATEGY COMPONENTS

Strategy Concept	Capital (Construction)		Operation and Maintenance		Replacement		Present Worth ('82)
	FY*	Capital $M	FY*	$K	FY*	$K	$M
Excavate, Solidify and Landfill - In Situ	1986	23.9	1988 - 1992 1993 - 2017	243 228	—	—	16.9
Excavate, Solidify, Transport and Landfill - RCRA On RMA	1986	23.6	1988 - 1990 1991 - 1992 1993 - 2017	233 169 145	—	—	16.4
Excavate, Solidify, Transport and Landfill - RCRA Off RMA	1986	72.6	—	—	—	—	43.0

*The fiscal year shown is used only for the purpose of carrying out the present worth cost analysis and should not be construed as the programmed start date.

The capital investment for the off-site disposal is over three times that of the other two concepts. Even considering effective operation and maintenance costs for on-site alternatives, the present worth for the off-site is 2.5 times that of either of the other two choices. The concepts of in situ closure and RCRA on-site closure are roughly the same in capital and present worth value.

5.3.3 Environmental Benefit/Technical Risk

5.3.3.1 Regulatory Acceptability

Basin F must be closed in accordance with RCRA/State regulations. A closure plan detailing the intended approach for deactivation of Basin F is required to be submitted to USEPA by April 1983. Discussion and subsequent negotiations are expected on any of the three alternatives that are presented within the closure plan. Assuming agreement can be reached on any areas of concern, a final solution to Basin F that is regulatorily acceptable will result.

5.3.3.2 Time to Implement

All three alternatives utilize the pacing element of solidification. Not until the Basin F fluid reaches a solids content of at least 40-50% will solidification be cost effective. Utilizing current evaporation techniques, this level is expected to occur between 1986-1987. Time is available to program any of the alternatives by 1988.

5.3.3.3 Availability of Proven Technology

Excavation, transportation, landfilling and capping are all available techniques. However, solidification of the liquid and sludge material requires matching the correct mixture of additives with the waste water to insure that the final product possesses the required physical and chemical integrity. To date, silica based mixtures appear to possess these required properties. Pilot studies are now being conducted to ensure these results are accurate on a large scale test.

5.3.3.4 Availability of Data

Significant efforts have been expended on problem definition and treatment technology development concerning Basin F. Until recently, when a major portion of the Basin bottom was accessible, no data was

available concerning contaminant levels in soils beneath the liner. Even now, this data is limited to the 40 acres of the southern portion of the basin. The cost estimates presented in Table 5-1 extrapolate the same pattern of minimal contamination beneath the liner to all portions of the Basin. This is the biggest assumption with regard to available data and mainly affects the two landfill options remote from Basin F.

5.3.3.5 System Compatability

Closure of Basin F and placement of all hazardous materials within an approved RCRA/State landfill is compatible with any other source excavation and landfill option at either Basin A, South Plants or the Railyard. However, the use of an in situ closure at Basin F would not be compatible with the other excavation options, since additional introduction of wastes to Basin F without a bottom liner will likely meet with resistance within the closure plan approval process. Futhermore, addition of new wastes to the Basin could also affect the conditions of closure under Parts 264 and 265 making the closure more costly.

5.3.3.6 Army Liability

The Army will maintain liability for disposal of hazardous materials from Basin F no matter which of the three concepts are chosen. However, the liability associated with off-site disposal appears more risky. First, transportation of solidified hazardous wastes over the long distances on public roads have the risk of accidental discharges. Second, the Army would have no control over the operation of an off-site facility, and thus no way of ensuring that the facility was operated properly. Lastly, the Army has no way of protecting itself if the operator should become financially insolvent thereby not being able to provide proper post closure care of the wastes.

5.3.4 Selected Concept for Basin F

Closure of Basin F seems to be relatively effective for either of the on-site methods. Transportation to an off-site RCRA landfill is not viable, based upon the capital and resulting present worth costs. Costs for the remaining alternatives are equal within the accuracy of the analysis.

The closure using an on-site landfill has the following advantages: it centralizes the Basin F waste into an area that will most likely remain under Army control, it will consolidate the RMA waste

materials, and will provide a leachate check system in the event of a problem with solidification over time. Additionally, the North Boundary system could be shut down once the Basin F area and north areas are flushed. The disadvantage is that the estimates of the extent of contaminated soil are not completely reliable, as there are no data presently available to confirm the assumption of contaminated volume assumptions made beneath the liquid portion of the Basin.

The in situ has the advantage that a smaller volume of soil will be handled and only one site need be monitored. Disadvantages are that it does not consolidate waste, and that there is no positive containment of any leachate as a result of solidification failure at the source. The boundary treatment system would be the site at which any contaminated ground water would have to be caught and treated in this eventuality.

Based upon the above discussion, it is recommended that the RCRA on-site concept be programmed, but that data gaps, particularly with respect to the extent of soil contamination under the present liquid pool be confirmed as soon as practical. If the extent of this contamination differs greatly from the present estimates, then consideration of the in situ closure should be reexamined and both concepts reevaluated.

5.4 STRATEGY COMPONENT SELECTION FOR DISCRETIONARY ACTIONS AT BASIN A/SOUTH PLANTS

5.4.1 Description of Components

5.4.1.1 Physical Barrier at A "Neck" with Physical and Chemical Treatment

This concept will stop the migration of contaminated ground water moving out of Basin A through the only exit, an alluvial channel called A "neck". The approach to be taken includes the installation of a physical barrier perpendicular to the exit channel, placement of dewatering wells on the southeast side of the barrier, recharge wells on the northwest, and use of chemical and physical treatment of the ground water. Treatment will include chemical pretreated, and adsorption by activated carbon. The expected flow through the system is approximately 40 gpm.

5.4.1.2 Cap Basin A

As noted eariler, Basin A currently exists as a 100 acre barren region within Section 36. Surrounding Basin A there are 80-100 acres

of semi-barren areas resulting from solid disposal operations during the past 30 years at the Arsenal. The concept of capping Basin A would preclude infiltration of surface water, within the barren and semi-barren regions of Section 36, from mobilizing contaminants currently in the unsaturated zone. The capping technique would require scanning the surface for unexploded ordnance, filling the low portions of the basin, capping the 200 acre composite site with clay, covering with topsoil and seeding. Adequate drainage patterns would be established so that surface water runoff would be diverted to uncontaminated areas of the Arsenal. A ground water monitoring program would be included to monitor the success of the concept.

5.4.1.3 Bentonite Barrier at A "Neck" with Treatment and Capping of Basin A

This concept is a combination of the two concepts presented above. The intent would be to stop and treat ground water, while reducing the volume of water treated due to surface infiltration.

5.4.1.4 Monitor Basin A Ground Water and Soil

The response action of monitoring would require the installation of additional monitoring wells and the implementation of soil and ground water analysis. This would allow the quality of the water and soil in the Basin A Area to be monitored as an early warning to changes in source conditions.

5.4.1.5 Dewater South Plants Mound with Physical and Chemical Treatment (with and without placement of A "Neck" barrier)

This technique is designed to stop the migration of contaminated ground water presently existing in an artificially induced water mound beneath the South Plants Area. The approach includes the installation of a dewatering field within the area of the mound, treatment of the evacuated ground water, recharge of the treated water in the Basin A "Neck" area and/or Lake Ladora, and monitoring of the system effectiveness. The mound will be pumped down to 5220 feet (MSL) at a rate of 300 gallons per minute (gpm). Once stabilized, a steady state of about 30 gpm will be needed to maintain the required gradient of the water table. Treatment of the water will likely include chemical addition, air stripping and carbon adsorption.

Depending on whether the proposed concept of the A "Neck" barrier is chosen, two variations exist because of the interaction of the Basin A and South Plants Areas. If the A "Neck" barrier system is

not installed, additional wells would be required in this concept to handle recharge of treated water, which will increase the cost of the concept. Both options will be discussed in the following sections under cost and environmental benefit/technical risk.

5.4.1.6 Dewater South Plants Mound with Physical and Chemical Treatment and Physical Barrier (With and Without Placement of A "Neck" Barrier)

This concept utilizes the same techniques as Section 5.4.1.5 above, with the addition of a physical barrier between the well field and the Lower Lakes area. The barrier would be approximately 9500 ft long, with an average depth of 50 ft. It would eliminate the influence of the Lower Lakes on the mound, and provide added assurance that the contaminants in the mound will not migrate south to the large aquifer under the Lower Lakes area.

5.4.1.7 Surface Water Management

The purpose of this concept is to capture surface water runoff from the South Plants Area to prevent its infiltration to the mound and divert it from Basin A to acceptable outfall points. Three drainage basins would be utilized. One would divert uncontaminated runoff to Lake Ladora; another would divert uncontaminated runoff to First Creek; and the third would divert runoff that was possibly contaminated to a retention basin for treatment, if necessary, at an existing treatment facility.

5.4.1.8 Monitoring South Plants Ground Water

Implementation of a monitoring program in the South Plants Area as a response action will be used for the purpose of documenting ground water hydrology and chemical quality, as an early warning of changing source conditions. This option would require the installation of several new monitoring wells and the development of a ground water sampling and analysis protocol.

5.4.2 Cost

Capital, operation and maintenance, replacement and present worth costs for the eight Basin A/South Plants Area components have been developed (see Appendix E) and are presented in Table 5-2. Options are included for the two alternatives incorporating South Plants Area mound dewatering to take into account the presence or absence of recharge capacity at the A "Neck" area. Expected shutdown of the Northwest Boundary System in year 2007 has been factored into operations/maintenance (O/M) and present worth costs for the

TABLE 5-2
COSTS FOR BASIN A AND SOUTH PLANTS STRATEGY COMPONENTS

Strategy Component	Capital (Construction)		Effective Operation and Maintenance		Replacement		Present Worth ('82)
	FY*	$M	FY*	$K	FY*	$K	$M
a) Physical Barrier at A "Neck" with Chemical and Physical Treatment	1987	4.27	1988 1989 - 2006 2007 - 2017	360 285 (-32)**	1997 2007	120 1,630	3.70**
b) Cap Basin A	1987	22.0	1988 - 1992 1993 - 2017	115 81	—	—	13.3
c) Physical Barrier A "Neck" with Treatment and Capping of Basin A (a + b)	1987	26.3	1988 1989 - 1992 1993 - 2006 2007 - 2017	475 400 366 49	1997 207	120 1,630	17.0**
d) Monitor Basin A Ground Water and Soil	1984	—	1984 - 2017	134	—	—	1.11
e) Dewater South Plants Mound with Physical and Chemical Treatment							
(1) With A Neck Barrier	1987	5.62	1988 1989 - 1990 1991 - 2017	964 814 590	1997 2007	240 4,130	7.45
(2) Without A Neck Barrier	1987	6.15	1988 1989 - 1990 1991 - 2017	964 814 590	1997 2007	250 4,580	7.80
f) Dewater South Plants Mound with Treatment and Physical Barrier							
(1) With A Neck Barrier	1987	11.7	1988 1989 - 1990 1991 - 2017	964 814 590	1997 2007	240 4,130	11.1
(2) Without A Neck Barrier	1987	12.2	1988 1989 - 1990 1991 - 2017	964 814 590	1997 2007	250 4,580	11.4
g) Surface Water Management	1987	1.2	1988 - 2017	126	—	—	1.41
h) Monitor South Plants Groundwater	1984	0.23	1985 - 2017	235	—	—	1.95

*The fiscal year shown is used only for the purpose of carrying out the present worth cost analysis and should not be construed as the programmed start date

**Assumes Discontinuation of Northwest Boundary System in Year 2007

components incorporating A "Neck" control. A negative O/M cost is shown, for example, within the first component reflecting a $17,000 savings per year over operating the Northwest Boundary System. Hence, this O/M column denotes effective "Cost" that must be added to baseline O/M for an actual cost (see Appendix E for further details on this methodology of cost estimating).

Initiation of monitoring response actions has been assumed for 1984. Implementation of all other systems will require extensive funding, appropriation and design lead time. A 1987 construction year has, therefore, been assumed as the earliest possible date for capital expenditures. All ground water control components include a first year cost for system stabilization. The South Plants Area mound dewatering includes a three (3) year operating period to initially reduce the mound and then a lower cost for maintenance of the dewatered condition. Basin A Cap O/M includes a five (5) year initial reseeding program to assure a satisfactory vegetative cover has been established.

5.4.3 Environmental Benefit/Technical Risk

Due to the complex interactions, that exist between strategy components in the Basin A/South Plants Area, a discussion broken into separate benefit/risk elements, as with Basin F, will not be possible. This Section will, therefore, address the components in the order that they appear in Table 5-2 starting with the first four alternatives for Basin A control.

Chapter 2 and Appendix C provide an understanding of hydrogeologic conditions at RMA. Ground water flows radially away from the mound beneath the South Plants Area. A major component of this flow proceeds under Basin A, through A "Neck" and onto the Arsenal boundaries. Contaminants are present in this flow regime due to spills, leaking pipes and percolation of surface liquids, and are being released from the Basin A and South Plants Area source areas at various rates. While in the low permeable Denver sands (denoted by the blue areas on Figure 2-5), the pollutants move very slowly (e.g., tenths of inches per day). Once these contaminants migrate into the highly permeable alluvium, their rate significantly increases (e.g., feet per day). Estimates of ground water travel time between the sources and the boundaries have been compiled in Figure 5-2 as an approximation of contaminant travel time.

The travel of ground water from the heart of the South Plants Area to its outer limits has been estimated to take from 34-68 years. Within Basin A, travel time is estimated between 17-34 years. One important point to note from Figure 5-2, is the very rapid travel from the A "Neck" area to the northwest boundary (10-20 years) and from the

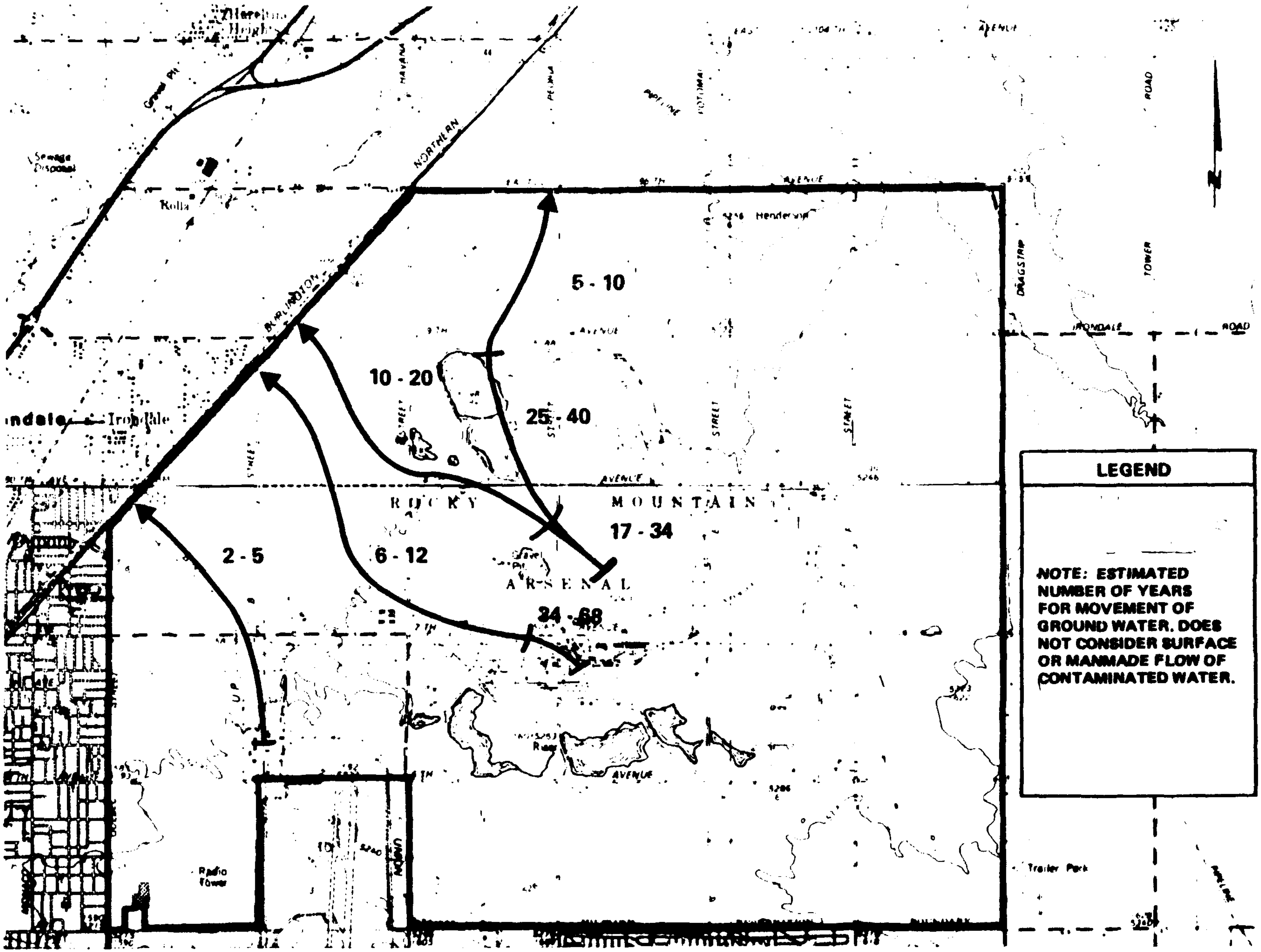


FIGURE 5-2
FLOW RATE OF RMA GROUNDWATER

South Plants Area to the northwest (6-12 years). Controlling these areas would isolate the sources and eliminate major contaminant release to the boundaries.

Of the control strategy components for Basin A, only a physical barrier at A "Neck" offers a positive degree of containment thereby reducing the Army's liability under CERCLA. The use of a physical barrier with dewater/treatment/recharge subsystems has been implemented successfully at the North Boundary of RMA. A subsurface injection permit was successfully obtained for the North Boundary system demonstrating regulatory agency acceptance of this mode of containment. The natural geologic necking occurring northwest of Basin A provides an area to optimally intercept contaminated ground water from multiple upstream sources. Additional advantages to this component are that the system utilizes off-the-shelf technologies easily implemented by FY88, and that downstream boundary operations can ultimately be shut down (assuming Basin F closure takes place). Termination of northwest boundary operations has been estimated to occur approximately 20 years after A "Neck" system startup. North Boundary operations will continue for at least 30 years, and therefore its termination was not considered in present worth analysis. At some point in the future it could be shut down unlike perpetual baseline operations without source control.

The capping of Basin A has been conceptualized as a means to reduce the infiltration of surface water and the movement of windblown contamination. Basin A is an area where surface water runoff from the South Plants Area and Section 36 accumulates. The soils in this area are considered relatively impermeable due to the addition of lime to the Basin in the past. Water does not appear to penetrate the surface crust covering the barren Basin unless a driving force is created by ponding water. When it does penetrate, as it has over the last 30 years, some leaching of residual contaminants from the unsaturated zone beneath Basin A is expected. The rate and flux of this leaching are unknown. Capping the Basin would also provide a more final form of windblown dust control beyond that being accomplished as part of baseline actions. However, neither expected outcome results in enough positive reduction in contaminant migration from the Basin A area to warrant the high cost associated with cap construction.

Capping Basin A combined with placing a physical barrier across A "Neck" would yield similar environmental benefits and technical risks as the individual strategy components just discussed. The principal interaction between the two systems would be a slight reduction of the volume and contaminant loading of ground water being handled by the A "Neck" system due to decreased infiltration in the Basin A proper. This reduction would likely be so minimal that underflow

from the South Plants Area mound would mask its significance in O/M costs. Again the capital cost associated with capping Basin A and the negligble benefits derived by the A "Neck" system does not justify further consideration of this composite strategy.

Monitoring Basin A, along with baseline and Basin F actions, does not offer any positive control of contaminant migration at the source area. Boundary systems would be relied upon to intercept contaminated ground water prior to its movement off-post. The environmental effectiveness of this concept is extremely low while its technical risk considering the Army's liability is high.

In summary, for control of contaminant release from Basin A, the concept of a physical barier across A "Neck" with physical and chemical treatment appears to be the optimal strategy component. Environmental benefits are high, technical risks low and present worth costs are reasonable.

With a preliminary selection of the control action for Basin A, evaluation of the strategy components for the South Plants Area is simplified. Unlike Basin A, which has only one known migration pathway for alluvial ground water, the South Plants Area has a number of places where contaminated ground water can exit (Figures 5-3, 5-4 and 5-5). Primary flow paths out of the South Plants Area are northwest through Section 35, north into Basin A, and south towards the Lakes. In order to control the South Plants Area as an individual source, the area must be contained via dewatering and treating of the anomalous ground water mound. Water table maps presented in Chapter 2, Figures 2-4 and 2-5, indicate the mound of ground water beneath the South Plants Area appears to be 30-40 feet above the natural water table evaluation. As stated before, most of the contaminants introduced in the South Plants Area were by surface spills or by leaking pipes close to the surface. By reducing surface infiltration and pumping the artifical ground water mound down, a significant reduction in contaminant migration within the aquifer can be effected. As in the case of Basin A, this would serve to isolate the contamination source within a local zone and allow boundary system termination.

The technology of dewatering a water table aquifer has been successfully accomplished in the Irondale treatment system. Data developed by Shell Chemical Co.[13] indicate that this method would be successful even within the complex Denver formation. Numerous wells would have to be installed, each with an approximate 200 feet radius of influence. The construction and operation of this system could be accomplished by the FY88 time with an estimated capital investment of $5,560,000.

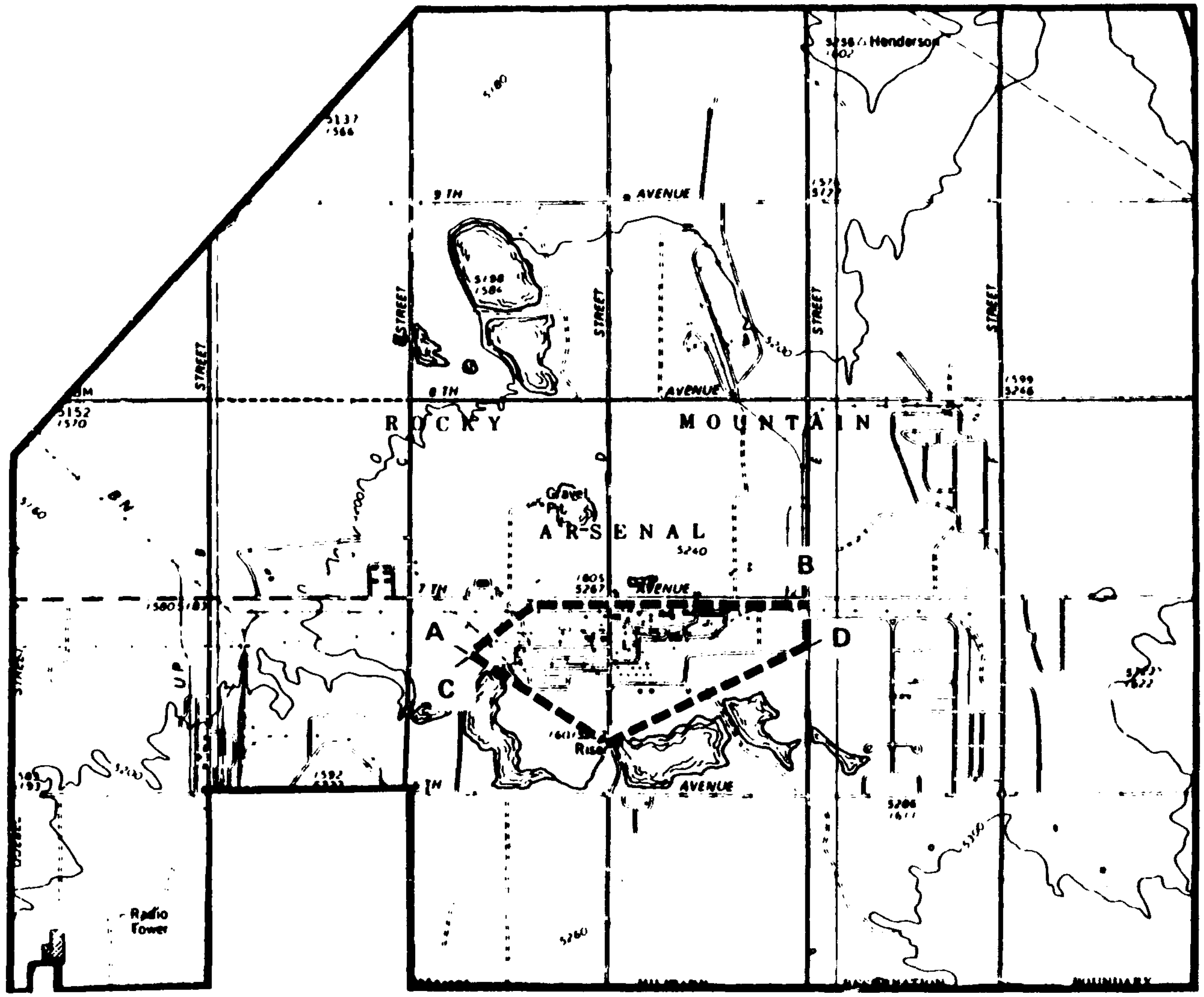


FIGURE 5-3
LOCATION OF CROSS-SECTIONS FOR
PLACEMENT OF SOUTH PLANTS
CONTROL AND CONTAINMENT SYSTEMS

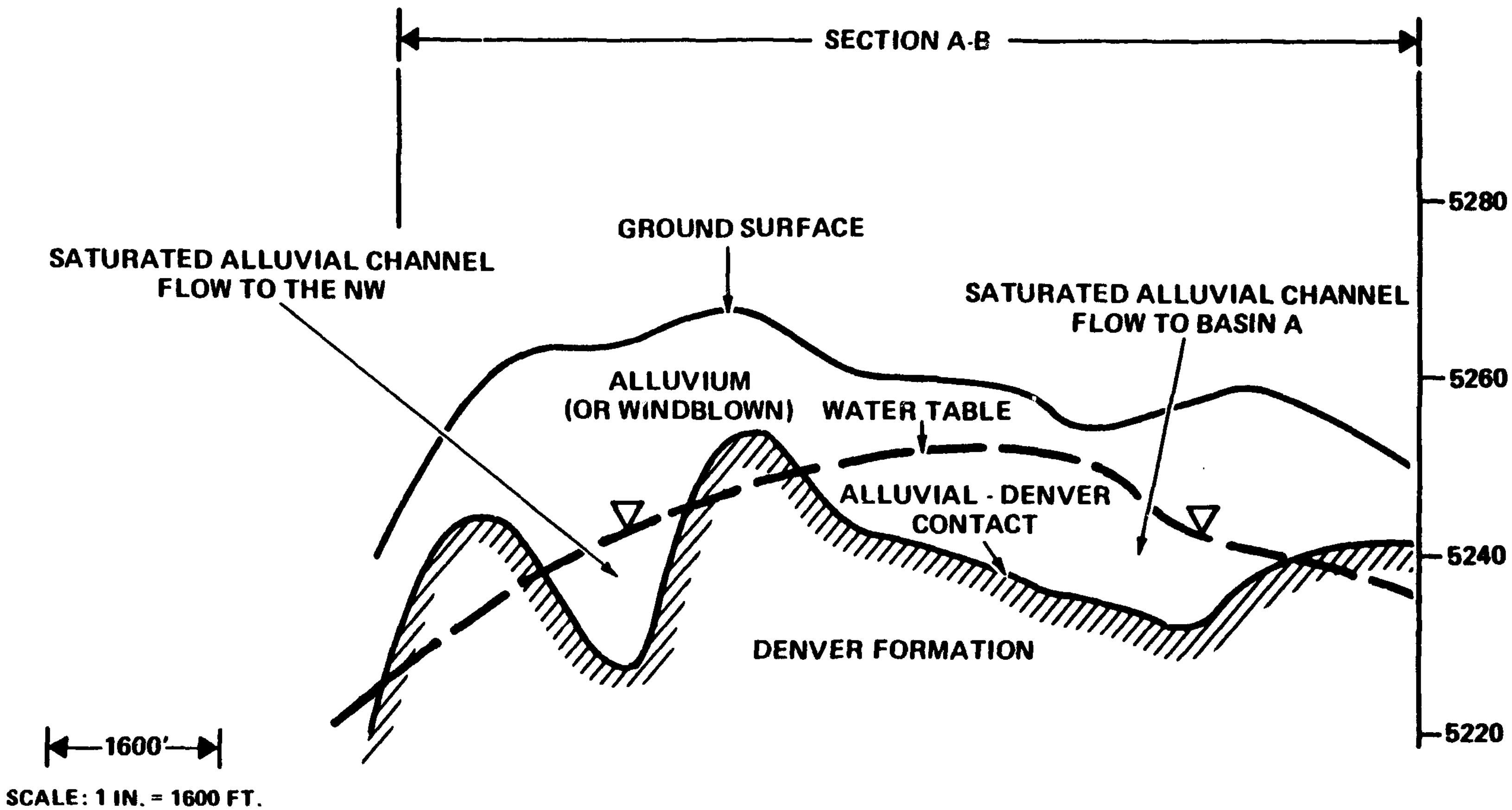


FIGURE 5-4
SECTION NORTH OF PLANT

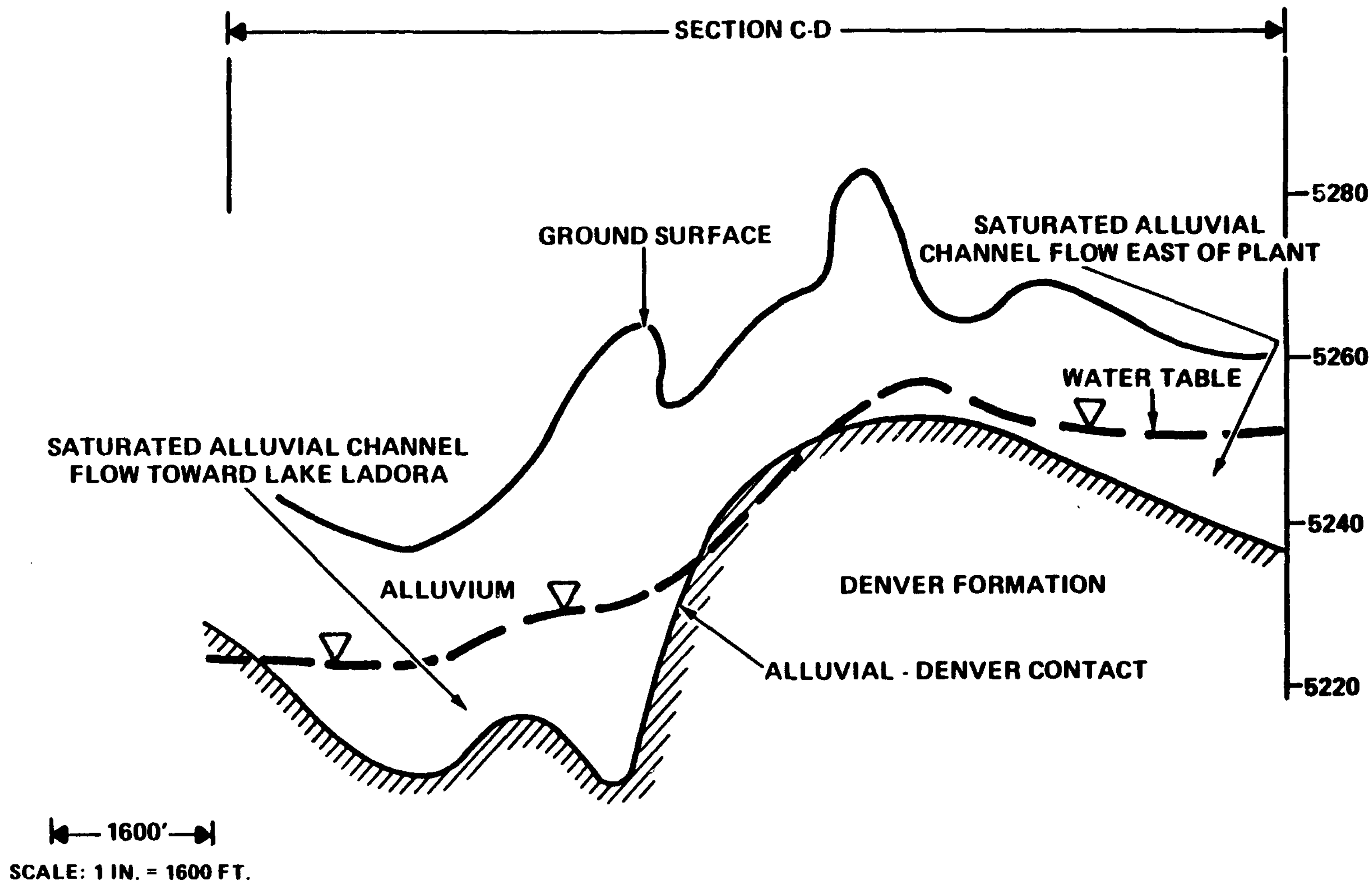


FIGURE 5-5
SECTION SOUTH OF PLANT

Dewatering of the ground water mound beneath the South Plants Area will not eliminate the source of release, but rather isolates it in an environmentally acceptable manner. Operation of this system will be required indefinitely, but significant reductions in the volume of water treated are expected when corrective actions are taken to eliminate leaking pipes in the South Plants Area. Due to the large environmental benefits derived by this concept, it is highly recommended that it be incorporated in the overall strategy concept for treatment of the South Plants Area as a contamination source.

The next strategy component for discussion is placement of a physical barrier between the South Plants Area and the Lower Lakes in conjunction with the dewatering of the mound. The purpose of including a physical barrier would be to eliminate the influence of the Lower Lakes on the water table in the South Plants Area and to serve as an added control measure if the dewatering operations were unsuccessful. Currently, the level of the mound is at or slightly above the elevation of the Lakes. It appears that the lakes, therefore, serve as a buffer to impede contaminant movement southward. If the lakes are maintained as planned (Ladora full - elevation 5220, Lower Derby at 16 feet - elevation 5255, and Upper Derby - dry) and the mound is reduced to 5220 MSL, then a buffer zone will be continued. A physical barrier could be installed to serve as more positive buffer, thereby, allowing the lakes to be maintained in any mode. If the mound cannot be dewatered to 5220 then the potential exists that contaminants could begin to move further southward and into the thick saturated zone beneath the lakes.

The rationale for adding a $6,000,000 physical barrier within the South Plants Area control system reduces to that of insurance. If the lakes are not maintained as projected or if the mound cannot be reduced to 5220 MSL then a physical barrier would be advantageous to preclude contaminant migration southward into high volume aquifer zones. This insurance is extremely costly for a slow moving contaminated plume that may arise. Time exists for barrier construction at a later date if either eventuality comes in existence since travel time within the South Plants Area is estimated in decades. Therefore, due to high costs and low environmental benefits, a physical barrier will not be considered further for the South Plants Area.

Surface water management in the South Plants Area is technically feasible, and would allow the diversion and isolation of contaminated surface water runoff. Since recharge of ground water is principally from unlined ditches, channels, and basins, many of which are located in areas of high concentrations of contamination, it is desirable to control or eliminate significant recharge in these areas. Two source areas where significant runoff and infiltration of contaminated surface water occurs are Basin A and the South Plants Area. Limited

contamination profiles of surface water flows in the South Plants Area show that concentrations of contaminants vary widely depending on (1) location, (2) magnitude of rainfall, and (3) the duration of the rainfall event. The uncontaminated water could be diverted to clean areas, such as First Creek and Lake Ladora. An additional benefit would be the gross reduction of surface water entering Basin A which would help reduce surface leaching of contaminants found in the soil. The estimated capital cost is $1,200,000, and could be initiated during FY87. This concept is considered environmentally beneficial, as it would decrease the size of the South Plants Area mound, and prevent spreading of surface-borne contamination. For these reasons, surface water management of the South Plants Area is considered a required action.

Monitoring ground water alone in the South Plants Area is not considered environmentally acceptable, as it does nothing to reduce or prevent the continued introduction of contaminants into the environment. For this reason, monitoring must not be the sole remedial action in the area, but must be done as part of the recommended actions.

5.4.4 Selected Concept for Basin A/South Plants Area

The strategy concept selected as most optimum in terms of cost, environmental benefit and technical risk is a combination of several components. The concept consists of:

a. Barrier A "Neck" with treatment.

b. Dewatering the South Plants Area mound without physical barrier.

c. Surface Water Management.

The total capital cost is estimated at $10,800,000 with a present worth value of $13,000,000 at 1982 dollars over an operational life of 30 years. This concept will isolate the contamination sources in both the Basin A and South Plants Areas, treat the surface and ground water, is believed to constitute an appropriate extent of remedy under CERCLA, with minimal liability of environmental harm and offers the potential for future shutdown of boundary treatment systems.

5.5 STRATEGY COMPONENT SELECTION FOR DISCRETIONARY ACTIONS AT THE RAIL CLASSIFICATION YARD

5.5.1 Description of Components

Strategy component selections for discretionary actions at the Rail Classification Yard are described as follows.

5.5.1.1 Hydrologic Barrier with Physical Treatment

The strategy component has been conceptualized to stop the migration of DBCP contaminated ground water as close to the source as possible. The hydrologic barrier would consist of dewatering wells on 200-ft centers that will extract a portion of the contaminated ground water. Recharge wells for the injection of treated water and monitoring wells would also be required. The physical (carbon adsorption) treatment system would be required to treat 50-100 gpm of ground water. Sampling and chemical analysis of ground water would be required to monitor the effectiveness of the system. This concept would allow the shutdown of the Irondale system by 1996.

5.5.1.2 Excavate, Transport and Landfill

In this concept, the area of the spill would be cleared of surface structures, and approximately 20,000 cubic yards of soil would be excavated and transported to the same disposal site as being used for Basin F. The excavation site would be filled, graded and revegetated. Ground water monitoring for DBCP would continue an estimated three (3) years to ensure that cleanup is effective. Irondale would be shut down by 1996.

5.5.1.3 Monitoring Ground Water

The concept of monitoring ground water would require the placement of additional sampling wells for early detection of changes in the DBCP concentration or change in ground water flow patterns. This concept would be in conjunction with the operation of the Irondale treatment system.

5.5.2 Cost

Capital, operation and maintenance, replacement and present worth costs for the three Railyard control components have been developed (see Appendix E) and are presented in Table 5-3.

A large range exists for the capital cost of the three concepts. The first concept of hydrologic barrier has not only the highest capital cost but also a high effective O/M and replacement costs. Even taking into consideration the cost savings in O/M from 1996 and beyond for discontinuation of the Irondale system, the present worth value is still $1,380,000. In the case of the excavation concept, the lower capital coupled with the savings of Irondale shutdown, produces a present worth of $180,000. Because of continued operation of Irondale, no reduction in the effective O/M is realized, in the case of "monitoring only," therefore, the present worth is costed at $540,000. On the basis of cost, the most effective system would be that of excavate, transport and landfill.

TABLE 5-3
COSTS FOR RAIL CLASSIFICATION YARD STRATEGY COMPONENTS

Strategy Components	Capital (Construction)		Effective Operation and Maintenance		Replacement		Present Worth ('82)
	FY*	$M	FY*	$K	FY*	$K	$M
Hydrologic Barrier with Carbon Treatment	1987	1.34	1988 1989 - 1995 1996 - 2017	225 176 3	1997 2007	30 1010	1.39**
Excavation, Transport and Landfill	1987	0.47	1988 - 1990 1991 - 1995 1996 - 2017	42 0 (-173)	—	—	0.18**
Monitor Ground Water	1984	0.13	1985 - 2017	58	—	—	0.54

*The fiscal year shown is used only for the purpose of carrying out the present worth cost analysis and should not be construed as the programmed start date.

**Assumes discontinuation of Irondale System in FY 1996.

5.5.3 Environmental Benefits/Technical Risk

5.5.3.1 Regulatory Acceptability

In Chapter 3 it was pointed out that sources, such as the Railyard, came under jurisdiction of CERCLA. The Irondale treatment system currently stops the migration of DBCP off-post, but does nothing to remove the continued introduction of DBCP into the ground water at the spill site. The concept of monitoring also does nothing to correct the continued introduction. The hydrologic barrier will stop the contaminant as close to the source as possible, while the concept of removal will remove the source entirely. Either appears to be a cost effective extent of remedy consistent with CERCLA.

5.5.3.2 Time to Implement

The concept of monitoring could be implemented by 1984 and the other two concepts by 1987. Therefore, all three concepts can be implemented by FY88.

5.5.3.3 Availability of Proven Technology

The technologies required in all three concepts are available and have been tested at sites on and off RMA. The least tested technology is that of a partial hydrologic barrier in the removal of contaminants on the uppermost part of an aquifer. Additional testing will be required, but success in applying this concept is anticipated.

5.5.3.4 Availability of Data

In the two source control concepts, additional definition of the contaminant site must be made. The strategy concept of excavation is most dependent on the volume of soil affected by the DBCP. Cost estimates will vary with any significant change in volume from that used in the calculations (e.g., 20,000 yd^3). The concept of a hydrologic barrier is not based on volume but that of area over which contaminated ground water must be captured.

5.5.3.5 System Compatability

The railyard does not interact with any other on-going system at RMA other than Irondale. Excavation, transport and landfill may have an impact on the permitting or environmental assessments for Basin F

since the landfill used for Basin F is also the site where contaminated railyard soils will be deposited. Installation of the hydrologic excavation systems will allow shutdown of the Irondale treatment system by 1996.

5.5.3.6 Future Control

By implementation of any of the three concepts, the Army and the lessee will be assured of the control of off RMA migration of DBCP. In the case of monitoring, the RMA is still allowing contamination to enter the ground water. By implementing a hydrologic control, a decrease in volume of ground water contamination will be achieved. Excavation would remove the source to a more controlled environment of a secure landfill. The Army and lessee would still be responsible for the control of the wastes, but a higher reliability is achieved through this action of containing any further release to the environment.

5.5.4 Selected Concept for the Rail Classification Yard

On the basis of environmental benefits and technical risks, the concepts of hydrologic control and excavation appear to be most acceptable. The cost favors the excavation concept because of the lowest present worth value, coupled with reasonable capital investment. This concept shows a present worth that is approximately one third of the simplest concept of monitoring. Based on the previous discussion, the concept of choice is the excavation, transport and landfill of soils from the Rail Classification Yard to the site where Basin F will be contained.

5.6 SUMMARY OF SELECTED CONTROL STRATEGY COMPONENTS

Throughout this Chapter a series of control strategy components have been selected using criteria of cost, environmental benefits and technical risk. Each has been chosen assuming independence from one source area to another. This assumption, based on computer model simulation of ground water flow, must now be re-examined and expanded to consider inter-system compatability to assure the overall optimum strategy has been identified.

Figure 5-6 presents a plan view of the major strategy components selected for Basin F, Basin A, South Plants Area and the Rail Classification Yard. These components when combined with baseline actions will make up the final contamination control strategy for RMA.

Of the components selected in this Chapter, only two involve active manipulation of the ground water regime. The A "Neck" system and

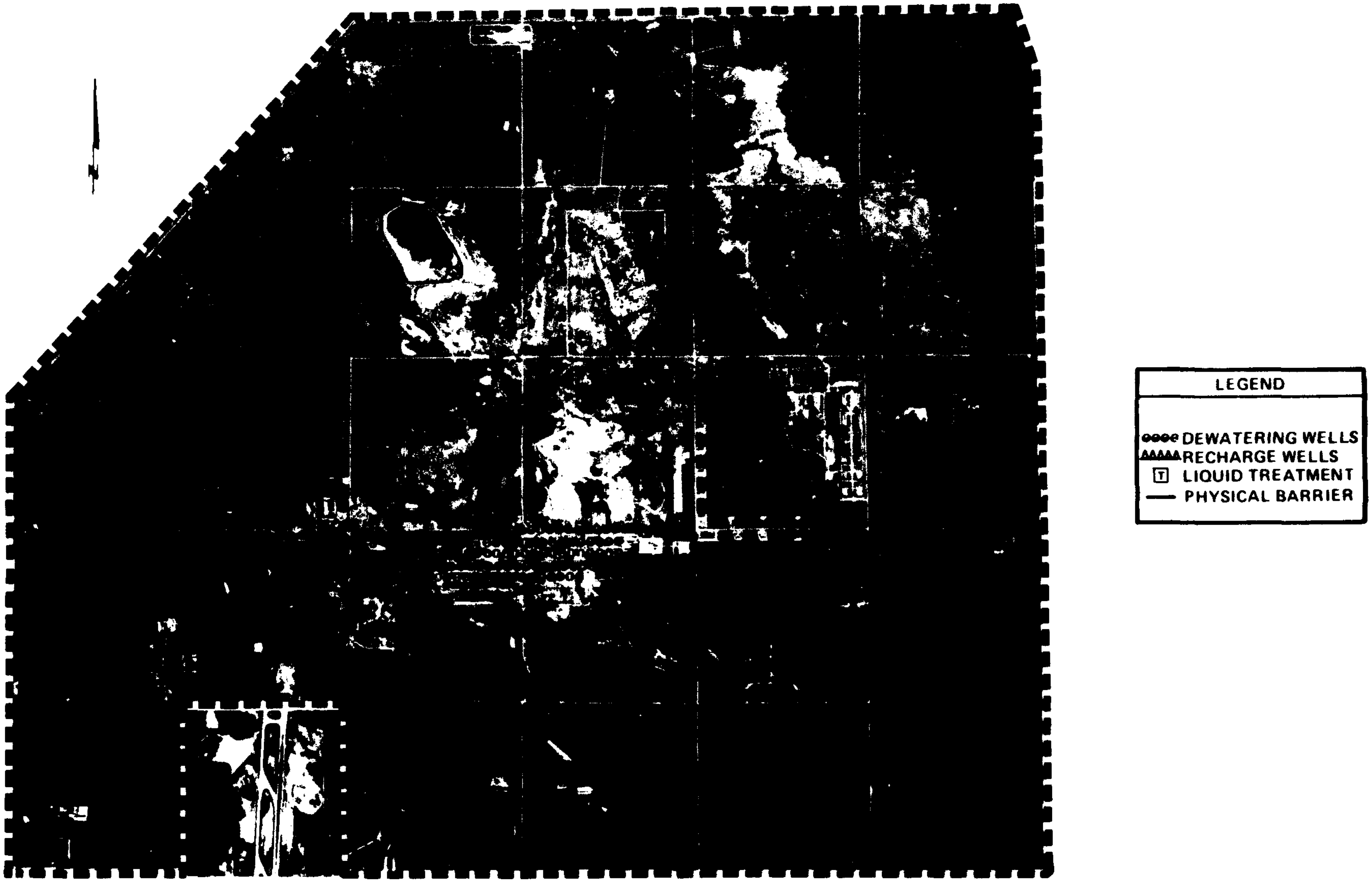


FIGURE 5-6
SUMMARY OF RECOMMENDED
CONTROL CONCEPTS

South Plants Area mound dewatering both involve dewatering/treatment/ recharge of ground water in the immediate area of a contamination source. The physical barrier across A "Neck" is similar in concept to the North Boundary system. Operational data from pilot and expanded operations have demonstrated that only local pertubations to the water table aquifer occur. Both immediately upstream and downstream from the system, the water table remains unchanged from presystem conditions. One would expect the same success for the A "Neck" system. The South Plants Area dewatering system is more complex, in that it seeks to change an anomalous condition (e.g., mound) into a more natural water table pattern. This objective is further complicated since the existing potentiometric surface beneath the plants is in the Denver formation. Several engineers and scientists have independently examined the geotechnical setting around the plants and concluded a dewater well array is feasible. As stated before, computer modeling has confirmed that this concept is plausible regionally, and downstream ground water effects can be minimized by the proper diversion of recharge to either A "Neck" or the Lower Lakes.

As part of the selection process, compatibility with existing systems was considered as part of technical risk. In addition, where applicable, compatibility between proposed strategy components was examined (e.g., disposal of Railyard contaminated soils with Basin F).

Overall, therefore, it appears that the combination of acceptable CERCLA and RCRA control strategy components for each of the source areas has resulted in composite strategy for the Arsenal. Chapter 6 will now summarize the final strategy and discuss the implementation of these recommedations.

CHAPTER 6
RECOMMENDED CONTAMINATION CONTROL STRATEGY FOR RMA

6.1 INTRODUCTION

The preceding chapters of this report have established the technical and regulatory rationale for development of response actions to assure RMA is in compliance with applicable environmental regulations pertaining to the discharge of pollutants to the environment. Selection of the final contamination control corrective measures was performed to realize environmentally adequate remedies with the lowest technical risk at the minimum present worth cost. The following sections will describe the recommended contamination control strategy for RMA in more detail and set forth technical and resource requirements for strategy implementation.

6.2 STRATEGY DESCRIPTION

The final contamination control strategy for RMA involves both the continuation of baseline activities (Chapter 3) and the implementation of new source control response actions (Chapter 5). This strategy, shown in Figure 6-1, meets the program objective defined within Chapter 1 while satisfying all constraints and assumptions set forth for the study. The strategy will reduce contamination at RMA to acceptable levels and is implementable by FY88. It encompasses both historic and ongoing operations that pose a potential for contaminant migration. Environmental impacts were considered in strategy component selection. Additionally, the strategy is not intended to address release of RMA and was not influenced by any future apportionment of costs among waste generators. The Lower Lakes will be maintained as planned. Both on- and off-site disposal options have been considered utilizing criteria consistent with environmental regulations.

Major environmental benefits of the strategy include (1) reduction of all contamination flowing off-post to acceptable levels, (2) positive action taken at each source area to contain contamination thereby allowing timely termination of existing boundary control system, and (3) action taken to eliminate contaminant migration by ground water, surface water, airborne and ecological release pathways. An added benefit realized by early termination of boundary control systems is that land used as buffer zones on RMA could be considered for future alternate land use.

Technical risks have been minimized by the incorporation of proven technology into the strategy components. The majority of new systems deal with containment of ground water or closure of Basin F which utilize technologies based on extensive background technical data.

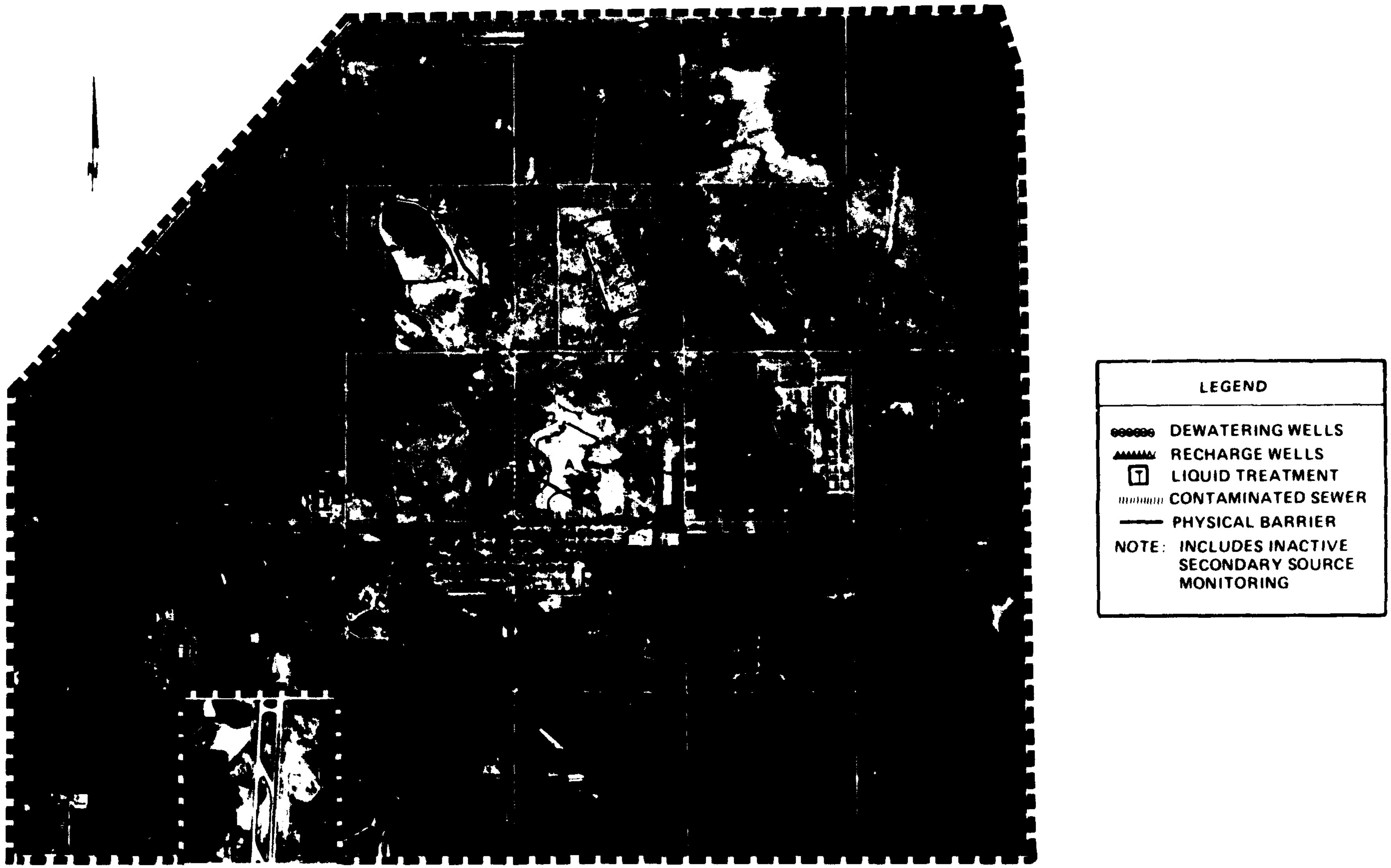


FIGURE 6-1
SOURCE CONTROL STRATEGY

Inter-system compatability was effected by careful selection of processes which have known success.

Overall capital cost for the strategy has been calculated to be $48,500,000 in 1982 base dollars (Table 6-1). Of this value, approximately one-half is associated with closure of Basin F. One should note that such costs for construction of the expanded north boundary, Basin F enhanced evaporation and Irondale control are also included. Operation and Maintenance costs over the 30 year present worth calculation period should total over $79,000,000 (1982 base dollars). Replacement of process equipment will occur at 10 and 20 years into system operations totaling almost $8,500,000 (1982 base dollars). These costs for contamination control at RMA appear reasonable and cost-effective.

Individual components of the overall strategy are discussed briefly in the following paragraphs. Ongoing, completed and programmed actions are presented on the unit operational level whereas planned actions are more generalized on the technology level.

6.2.1 North Boundary: Expanded Containment/Treatment - Ongoing Action

The containment system installed at the North Boundary of RMA consists of (1) a physical barrier (slurry wall), (2) dewatering wells to intercept the natural flow of ground water exiting along the northern boundary, (3) organic contaminant removal via a ground water treatment facility, and (4) recharge wells to reinject treated water on the downgradient side of the slurry wall. A generalized cross-section showing the vertical extent of the slurry wall and location of the dewatering/monitoring wells is shown in Figure 6-2. A schematic cross-section of the North Boundary system is shown in Figure 6-3.

The slurry wall was constructed of a bentonite soil mixture with a permeability of 1×10^{-7} cm/sec or less. The trench is approximately 6,750 feet long, four (4) feet wide and is keyed into the Denver formation at a depth of 25-50 feet. In some locations the slurry wall was extended deeper into the Denver formation to incercept some of the more permeable Denver sands.

The ground water flowing toward the barrier is extracted along the upgradient side of the barrier by 54 dewatering wells. The dewatering is achieved through three (3) separate pipelines (well header systems) and water is pumped to three (3) separate wetwells, where it is retained prior to treatment. The influent water to the

TABLE 6-1
COSTS FOR SOURCE CONTROL STRATEGY

System	Project Status	Capital Cost $M (1982)	O&M Year*	Effective O&M Cost Per Year $M (1982)	Replacement Year*	Replacement Cost $M (1982)	Present Worth $M (1982)
1. **Baseline**							17.4
a. North Boundary: Expanded Containment/Treatment	Ongoing 1980	4.32	1981 - 2017	0.302	1990 2000	0.12 2.16	
b. Basin F: Enhanced Evaporation and Contaminated Sewer Removal	Complete 1981	1.40	1982 - 1986	0.107	None	None	
c. Irondale: Containment/Treatment	Ongoing 1981	1.01	1982 - 2017	0.173	1991	0.05	
d. Northwest Boundary: Containment/Treatment	Programmed 1984	4.14	1985 1986 - 2017	0.392 0.317	1994	0.18	
e. Sanitary Sewer: Removal/Upgrade	Planned 1986*	1.43	None	None	None	None	
f. Basin A Windblown Dust Control	Ongoing 1982 1983*	0.09 0.08	every 5 yrs.	0.168	None	None	
g. Lower Lakes Sediment Removal	Planned 1983*	0.86	None	None	None	None	
h. Plugging of Deep Well	Planned 1985*	0.30	None	None	None	None	
i. Inactive Secondary Source Monitoring	Planned 1984*	None	1985 - 2017	0.478	None	None	
2. Basin F							
Onsite Landfill	Proposed 1986 1987*	23.64	1988 - 1990 1991 - 1992 1993 - 2017	0.233 0.169 0.145	None	None	16.4
3. Basin A and South Plants							
a. Neck - Containment/Treatment	Proposed 1987*	4.27	1988 1989 - 2006 2007 - 2017	0.360 0.285 (-0.032)	1997 2007	0.12 1.63	3.70
b. South Plants Mound Dewatering	Proposed 1987*	5.62	1988 1989 - 1990 1991 - 2017	0.964 0.814 0.590	1997 2007	0.24 4.13	7.45
c. Surface Water Management	Proposed 1987*	1.20	1988 - 2017	0.126	None	None	1.41
4. Rail Classification Yard							
Soil Removal	Proposed 1987*	0.47	1988 - 1990 1991 - 1995 1996 - 2017	0.042 0 (-0.173)	None	None	0.18
Total Years ($M 1982)	1980 - 1987	48.8	1981 - 2017	73.7	1990 - 2007	8.63	46.5

* The fiscal year shown is used only for the purpose of carrying out the present worth cost analysis and should not be construed as the programmed start date.

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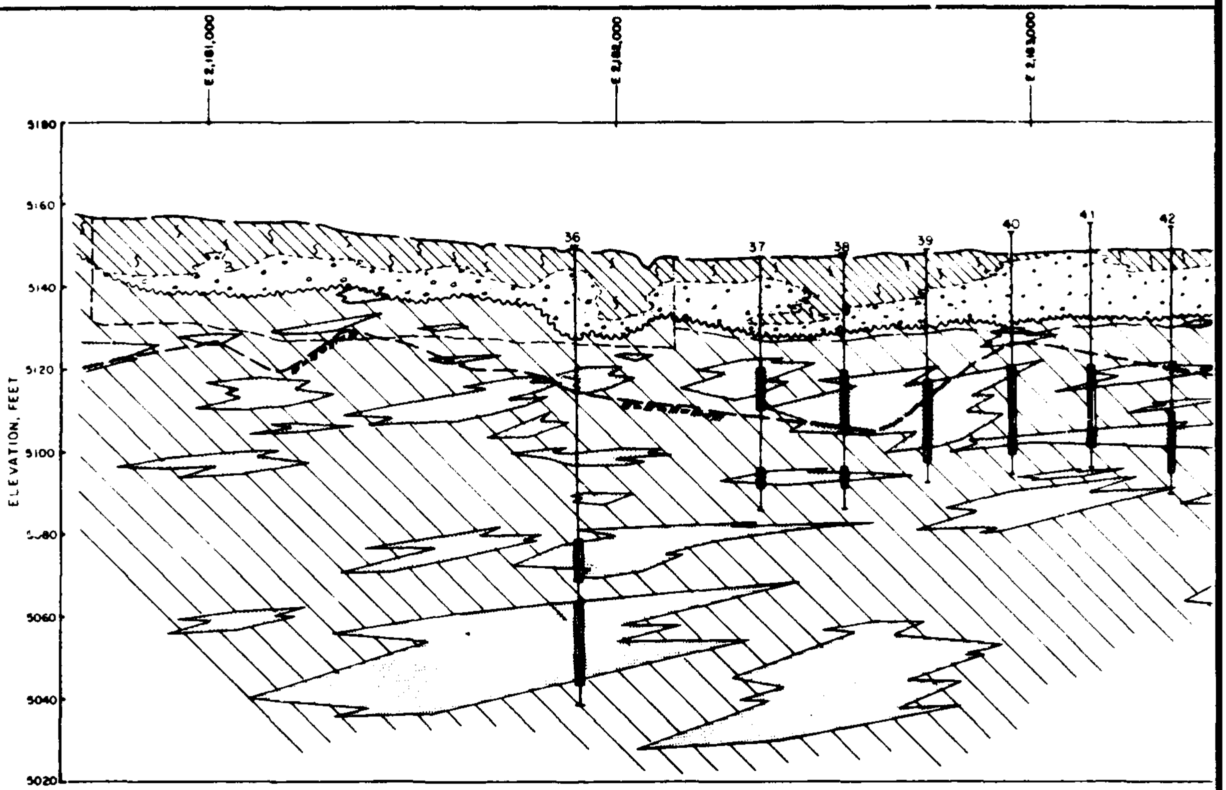
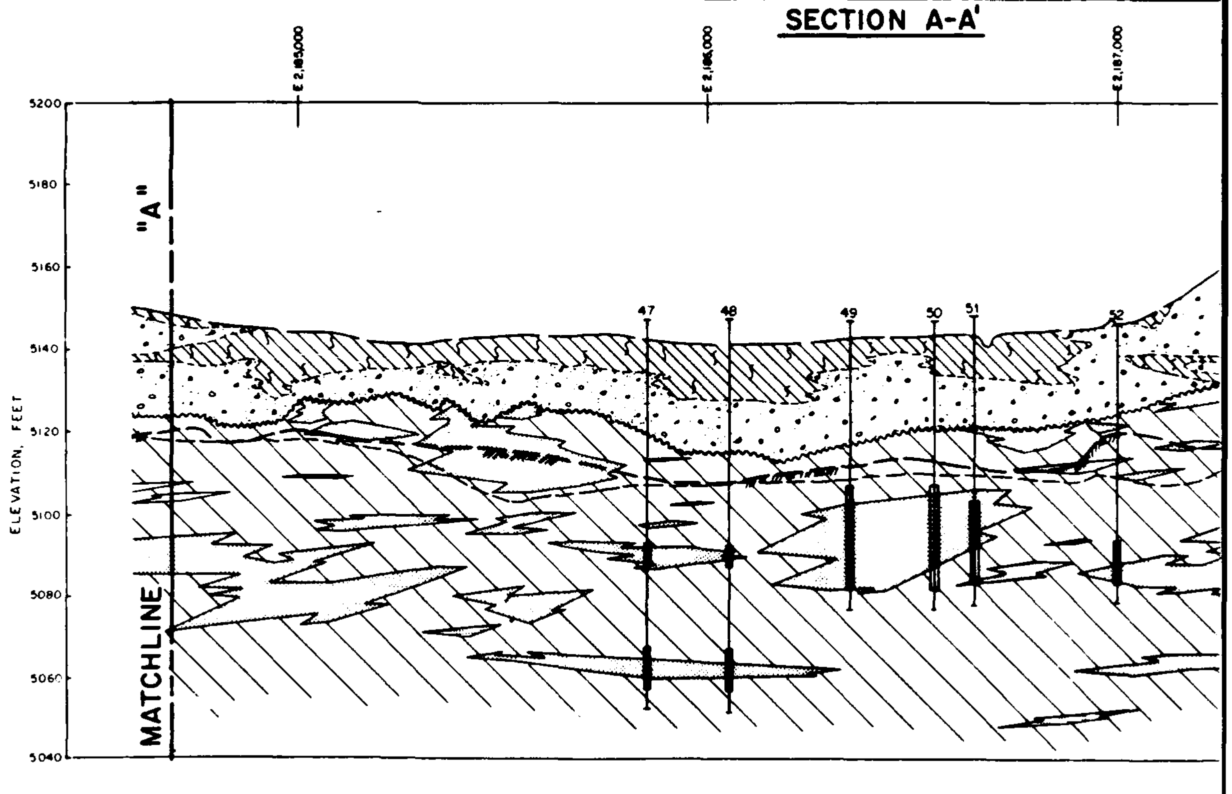
DRAWN BY	D.J.R. 5-20-80	CHECKED BY	APPROVED BY



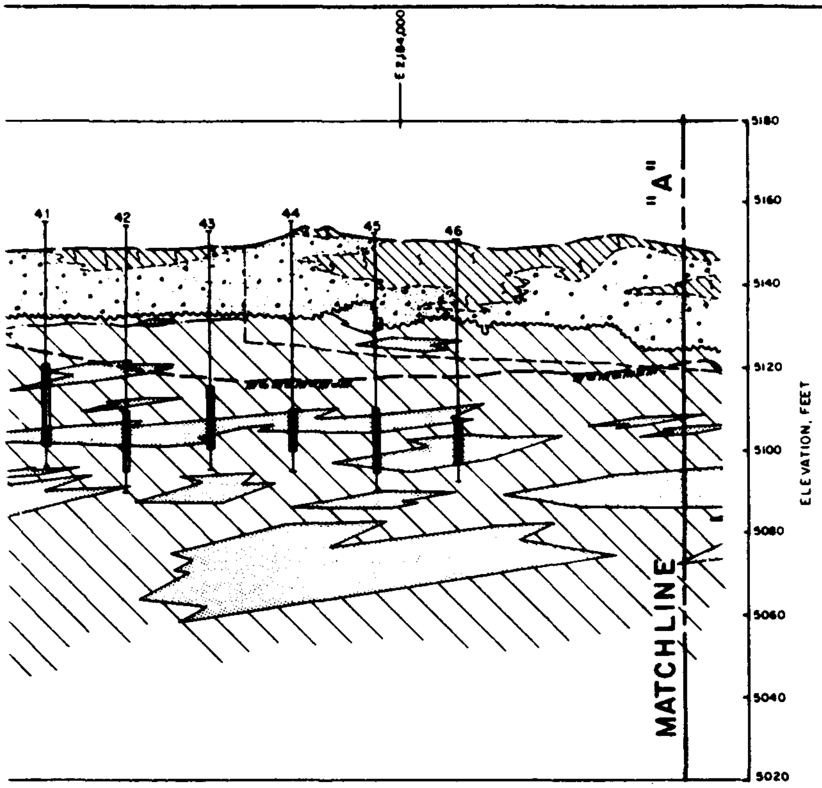
CROSS SECTION AT NORTH BOUNDARY SHOWING CONTAINMENT WALL A

SECTION A-A'

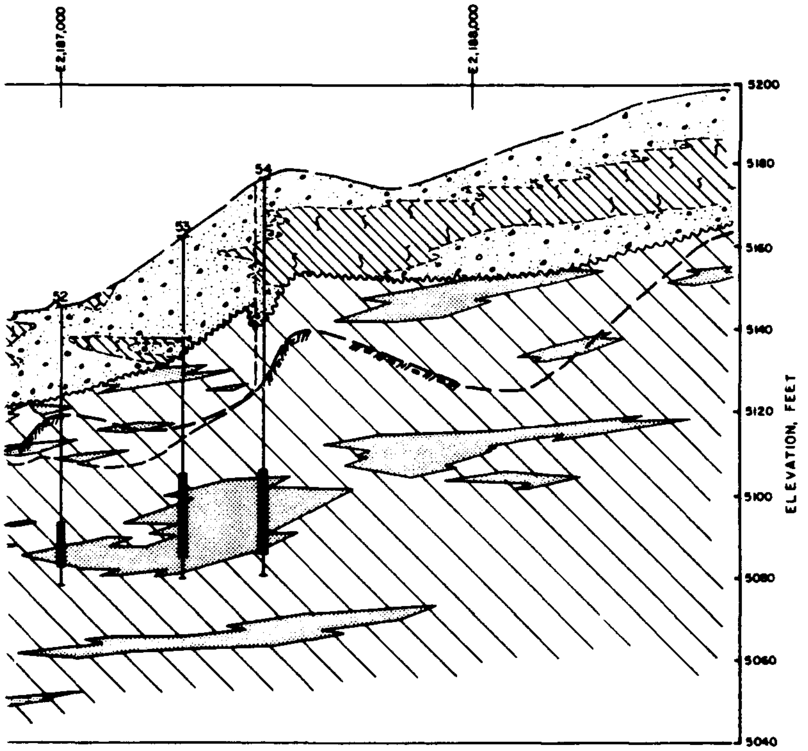


CROSS SECTION AT NORTH BOUNDARY SHOWING CONTAINMENT WA

(SECTION A-A' CONTINUED)



'T WALL AND DEWATERING WELLS



NMENT WALL AND DEWATERING WELLS

LEGEND

CONTACT BETWEEN ALLUVIUM AND DENVER FORMATION

DEPTH OF WEATHERING

CLAYS AND SILTS } ALLUVIUM
SANDS AND GRAVELS

CLAYSTONE } DENVER FORMATION
SANDSTONE (DENVER SANDS)

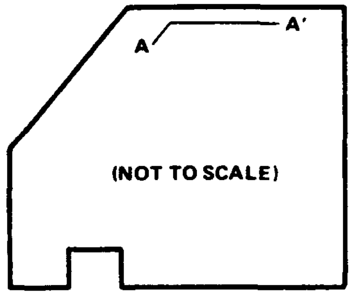
46 WELL NUMBER

DENVER SAND DEWATERING WELL

SCREENED INTERVAL (DEWATERING ZONE)

PROPOSED CONTAINMENT WALL DEPTH

PRESENT CONTAINMENT WALL DEPTH



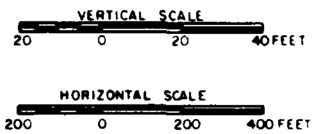


FIGURE 6-2

GENERALIZED CROSS SECTION SHOWING VERTICAL EXTENT OF CONTAINMENT WALL AND LOCATION OF DENVER SAND MONITORING/DEWATERING WELLS

(Ref. D'Appolonia Consulting Engineers)

2

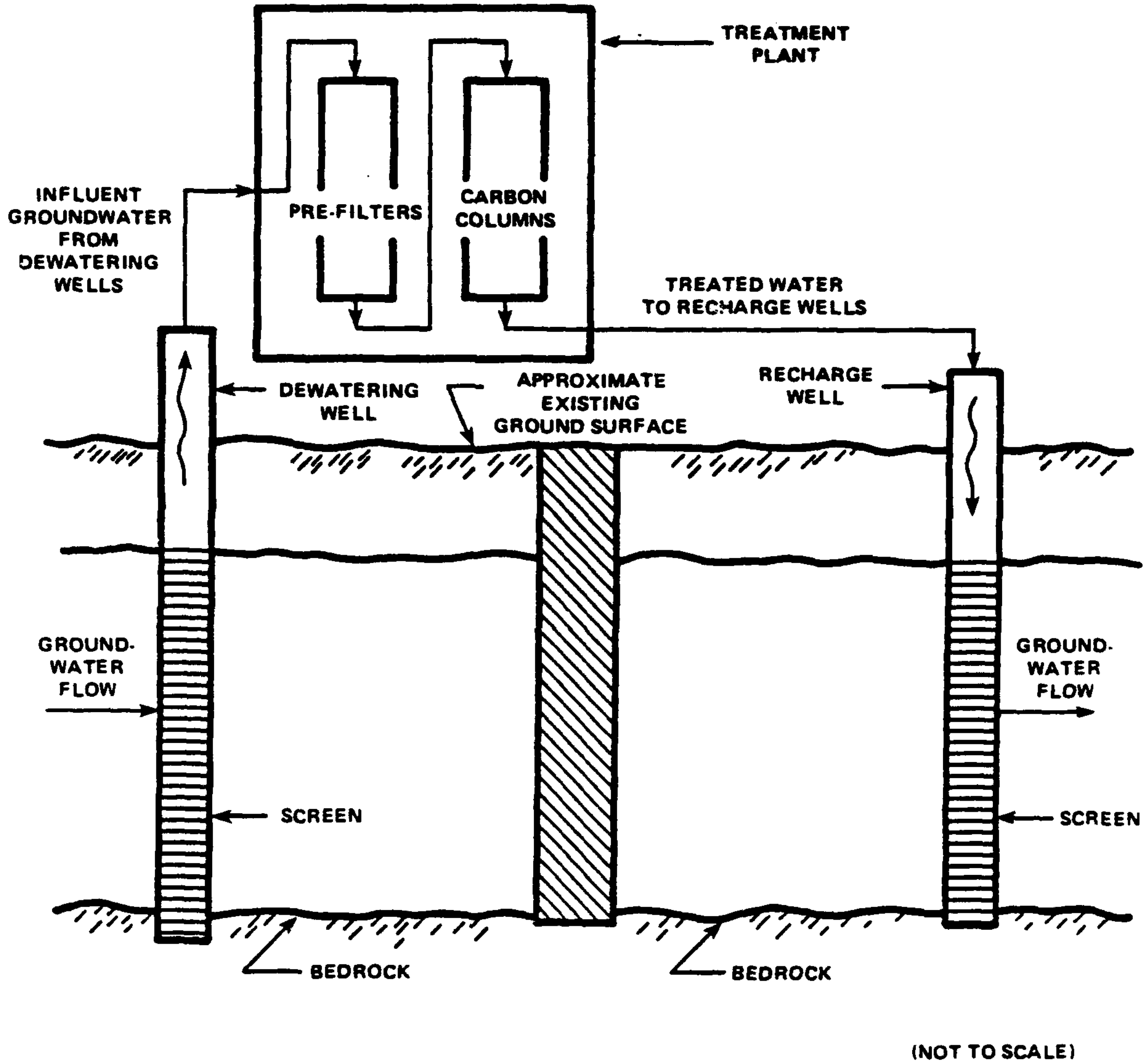


FIGURE 6-3
SCHEMATIC DIAGRAM OF NORTH BOUNDARY CONTAMINATION CONTROL SYSTEM

treatment facility is pumped from the wetwells through a pre-filter gallery of cartridge pressure filters to remove any sand or fines, prior to passage through a pulse-bed activated carbon column for removal of the organic contaminants. The treated water then flows to an effluent wetwell where it is pumped to a group of 38 recharge wells. The capacity of the treatment facility is 800 gpm.

6.2.2 Basin F: Enhanced Evaporation and Contaminated Sewer Removal - Evaporation Ongoing/Contaminated Sewer Removal Complete

The enhanced evaporation system consists of (1) construction of dikes on the dry surface of the partly evaporated Basin (Figure 6-4) and (2) spreading of the liquid over the entire surface of Basin F to maintain a maximum solar evaporation rate for the Basin. This measure is intended to enhance the evaporation of liquid in the Basin and minimize surface water inflow. Construction of this system was recently completed.

The removal of the contaminated chemical sewer was completed in June of 1982. This consisted of approximately 12,000 yd^3 of contaminated soil and the sewer line that was disposed of in a lined waste pile in Basin F.

6.2.3 Irondale: Containment/Treatment - Ongoing Action

The Hydrologic Control System installed at the southern part of the northwest boundary (referred to as Irondale area) is conceptually different from the physical containment facility installed at the north boundary, although the functional objective of each system is to stop migrating contaminants from exiting the Arsenal boundaries. The selection of the hydrologic system installed by Shell Chemical Company was based on a detailed geotechnical and hydrologic assessment of the location of the DBCP plume that was migrating off the Arsenal. The control system consists of two (2) rows of dewatering wells (18 in one row and 15 in the other) 800 feet apart and one row of 14 recharge wells, 600 feet northwest from the nearest row of dewatering wells (Figure 6-5). The dewatering and recharge wells are spaced 100 feet apart within each row. The treatment plant is located between the two rows of extraction wells. The dewatering wells pump the contaminated ground water to an influent water wetwell. The wetwell is maintained at a pre-determined water level via use of flow controllers. From the wetwell the water is pumped through a series of unit operations consisting of prefilters, pulse-bed carbon filters and post-filters. The capacity of the

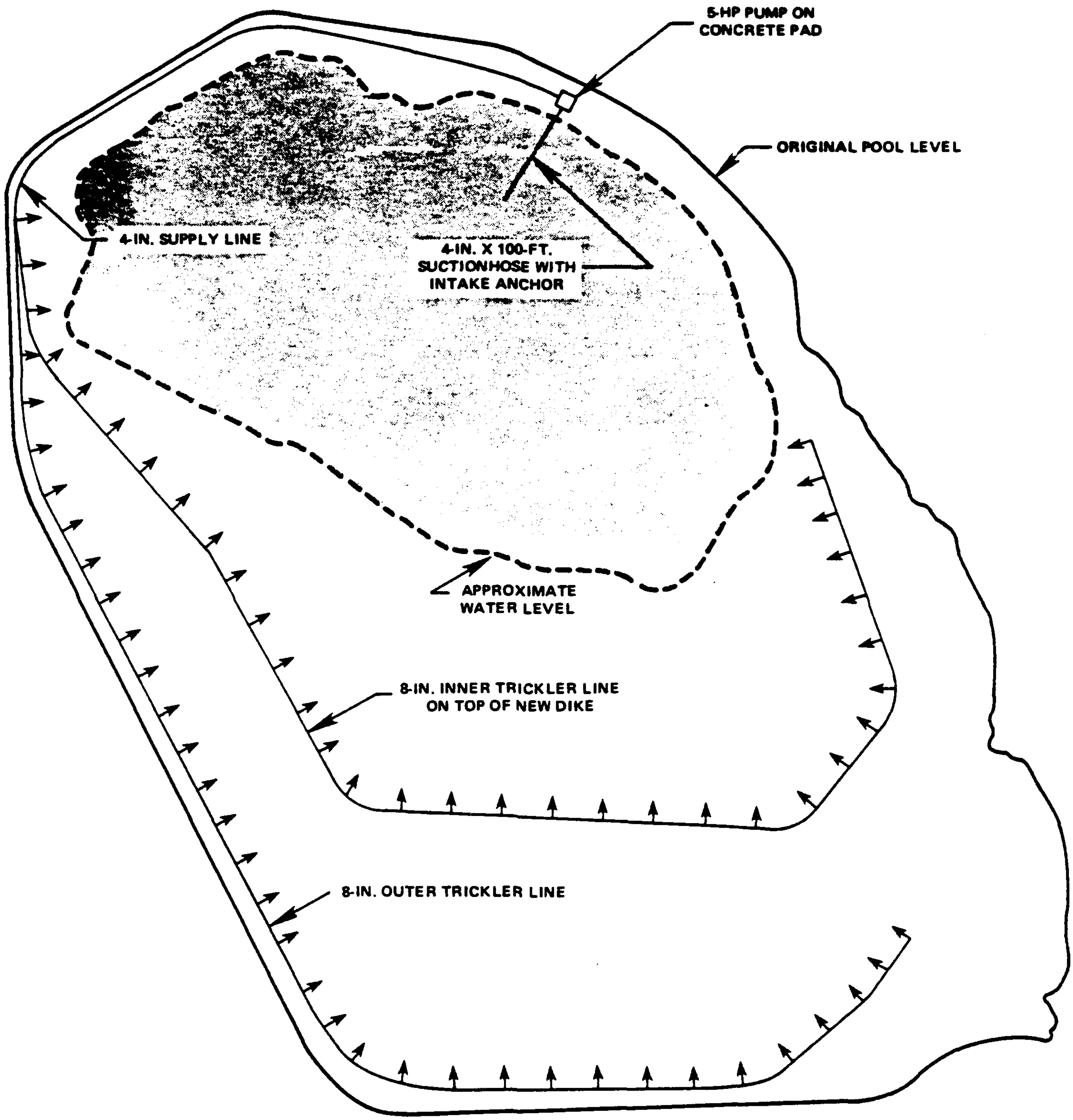
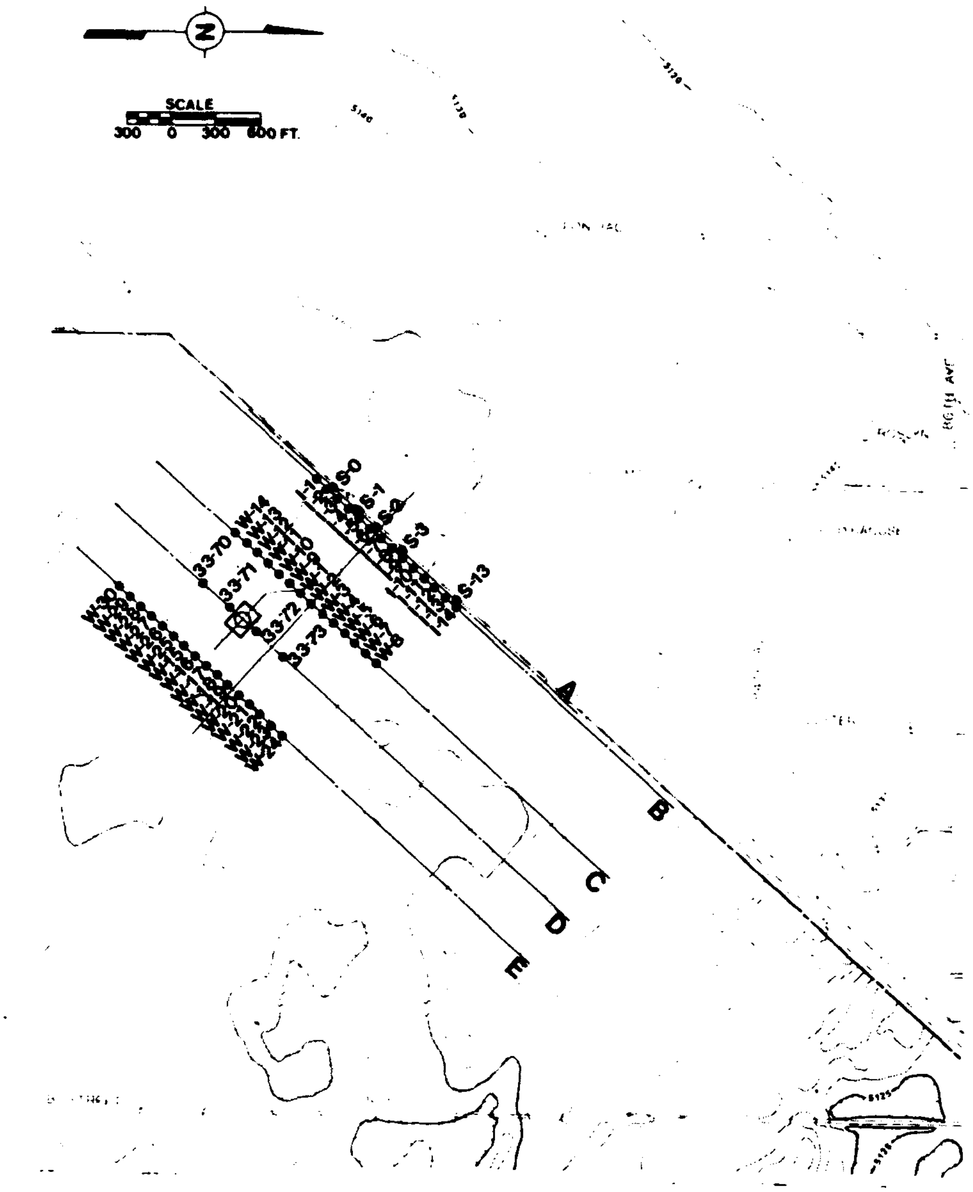


FIGURE 6-4
SCHEMATIC DIAGRAM OF BASIN F ENHANCED EVAPORATION



LEGEND

- ● WELL
- O TREATMENT PLANT AREA (150 FT. x 200 FT.)
- A EXISTING MONITORING WELLS
- B 14-RECHARGE WELLS SPACED AT 100 FT.
- C ROW NO. 1. 14-DEWATERING WELLS SPACED AT 100 FT.
- D 4-MONITORING WELLS SPACED AT 250 FT.
- E ROW NO. 2. 16-DEWATERING WELLS SPACED AT 100 FT.

NOTE

BASE LINE REFERENCES ON THE LOCATION OF EXISTING WELL NO. W-2.

FIGURE 6-5
IRONDALE
DBCP CONTROL SYSTEM
SITE MAP
(Ref. Rubel and Hager Inc.)

treatment facility is 1400 gpm through two (2) 700 gpm process trains. The treated water is pumped through a distrubtion system to the recharge wells.

6.2.4 Northwest Boundary: Containment/Treatment - Programmed Action

The northwest boundary control system is currently being designed by the Omaha District of the Corps of Engineers. This Military Construction Army (MCA) project is scheduled to be implemented by FY84. When the system is installed it will intercept the only known migrating plume of contamination presently uncontrolled at the boundaries. The containment system selected for design at the northwest boundary uses the technologies of a hydrologic barrier/ Bentonite Slurry Wall and a ground water treatment facility. The geologic conditions in the northwest boundary area of concern are similar to conditions in the area of the Irondale DBCP control system. This analogy has lead to the selection of a hydrologic barrier as the primary means for control of contaminants along the boundary. The bentonite barrier has been selected for use in areas where the saturated thickness is thin and the control of ground water flow using hydrologic barriers is impractical. Detailed geotechnical investigations for siting the proposed system are presently being performed by the Omaha District, prior to concept design. The primary difference between the Irondale system and the proposed Northwest Boundary System is a thicker saturated alluvium near the southwest end of the system. This condition will allow the hydrologic barrier concept to be used on the southwest end while the bentonite barrier concept will be used on the northeast end where the saturated alluvium is fairly thin. The combination of control concepts will allow for better control of the contaminatin plume. There are several contaminants both organic and inorganic found in the ground water at the northwest boundary. The concentration levels of organic contaminants are fairly low. DBCP is the only organic contaminant that has levels that exceed an acceptable water quality guideline. The concentration levels of inorganic contaminants is also fairly low with respect to the high levels associated with the contaminant sources.

A generalized cross-section of the RMA Northwest Boundary showing the proposed location of the system is shown in Figure 6-6. The system is planned to span approximately 2350 feet along the boundary. A plan view of the layout of the dewatering and recharge wells is shown in Figure 6-7. The present concept and the bentonite slurry wall consists of one row of 14 dewatering wells and one row of 21 recharge wells, 600 feet apart. The system is being designed to extract between 1200 gpm and 1500 gpm of ground water from the alluvium.

The proposed ground water treatment plant is similar to the one installed at the Irondale system. The technologies chosen for the

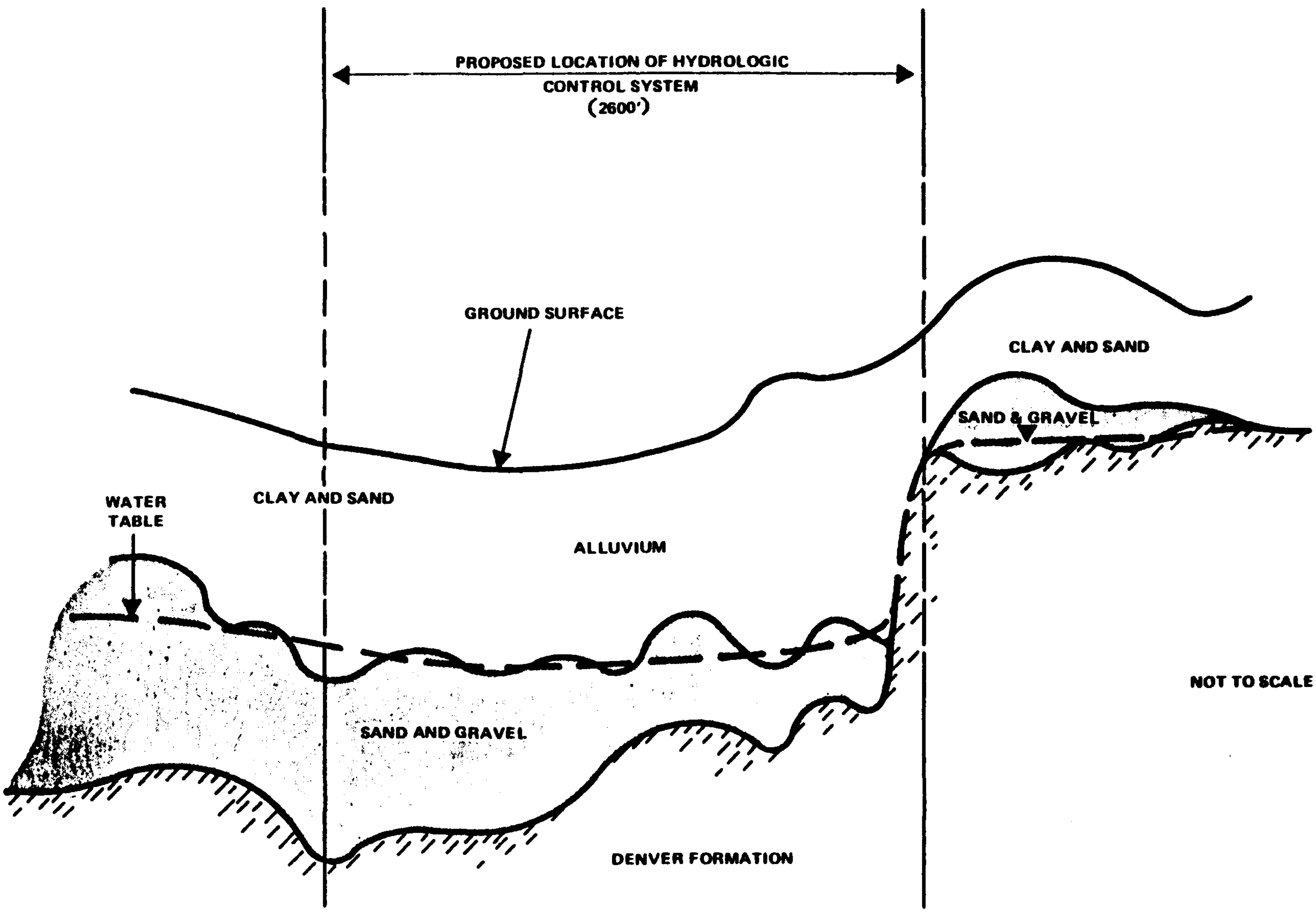


FIGURE 6-6
RMA NORTHWEST BOUNDARY SYSTEM CROSS SECTION

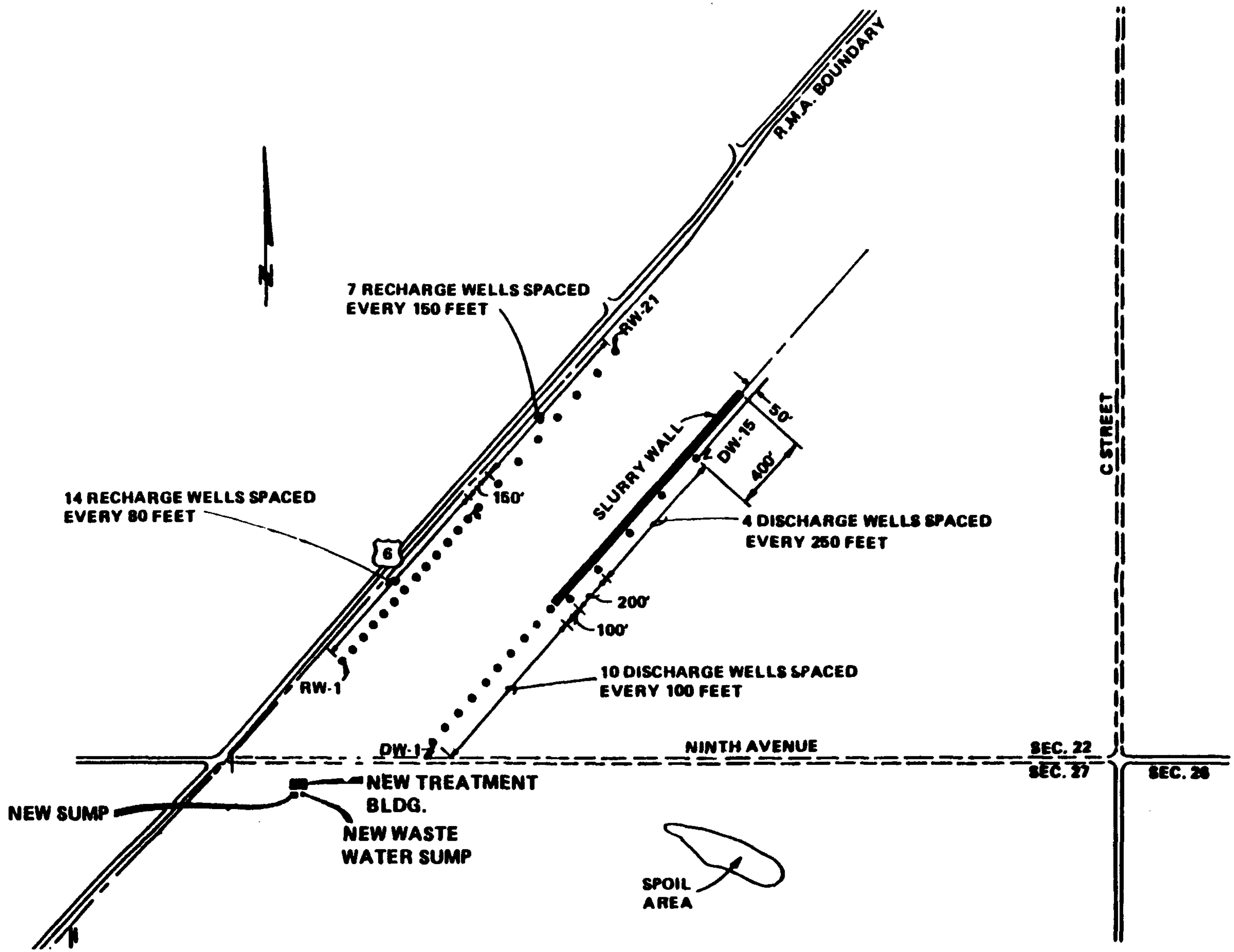


FIGURE 6-7
ROCKY MOUNTAIN ARSENAL
NORTHWEST BOUNDARY CONTAINMENT SYSTEM

design consist of filtration and carbon adsorption. Details of the concept design are not yet available, but the basic unit operations, as described for the Irondale treatment system (e.g. influent wetwells, prefilters, pulse-bed carbon columns with carbon transfer vessel, and post-filter) are likely candidates for the final design.

6.2.5 Sanitary Sewer: Removal/Upgrade - Planned Action

Three MCA projects are being considered to correct the problems encountered with the sanitary sewer system. The first action includes repair of the South Plants Area sewer lines to include lining and replacement; the second addresses the repair of the North Plants sewer lines; and the third will deal with the removal of the lines that link the North and South Plants Areas and the Administration area. Implementation of this remedial action will eliminate the rapid transport of contaminants presently entering the deteriorated sewers, along the line extending from the South Plants Area, through Basin A, and north to the North Boundary treatment facility.

6.2.6 Basin A: Windblown Dust Control - Ongoing Action

RMA has historically experienced periods of high winds and dry conditions which result in dust storms and wind erosion. Hazardous materials within Basin A have been found to be transported away from Section 36 to other locations on RMA. Two techniques were considered for treatment of Basin A to mitigate this contaminated dust transport; revegetation and synthetic surface stabilizers. Data from germination studies indicated that Basin A is not a candidate for revegetation without addition of a costly new soil base or extensive fertilization. As a result of these findings, application of a synthetic polyvinyl acetate dust palliate was chosen for field demonstration. Approximately 70 acres of Basin A have been treated to date. The sprayed areas will be monitored for effectiveness and additonal acreage will be covered if successful. Re-application of the surface stabilizer will be required every five (5) years to provide a long-term solution to the problem.

6.2.7 Lower Lakes Sediment Removal - Planned Action

During the fall of 1981, the Colorado Department of Health (CDH) and the Colorado Division of Wildlife, along with their counterpart federal agencies, expressed concern to Rocky Mountain Arsenal and to the local press about elevated levels of aldrin, dieldrin, and mercury in waterfowl sampled on the Arsenal. The levels of the toxic substances in waterfowl from the Arsenal exceeded the levels set by the Food and Drug Administration for consumption of fowl or fish by humans. The close proximity of local waterfowl hunting areas and the possibility of hunters consuming the waterfowl poses a potential threat to public health.

During the winter of 1982, a preliminary sampling and containment survey (20 samples) was completed on Upper and Lower Derby, the connecting ditches, and the Rod and Gun Club Pond. Aldrin and dieldrin were found to be present in concentrations in excess of levels that permit safe wildlife habitat.

Based on the preliminary survey, a formal sediment sampling and analysis protocol was developed to allow a detailed survey of the area. The data collected confirmed the presence of pesticides in significant concentrations within sediment beneath Upper and Lower Derby Lakes. A summary of excavation requirements to remove harmful aldrin and dieldrin concentrations is depicted in Figure 6-8. Funding has been requested to perform the required excavation and disposal.

The sediments of Lake Ladora will require sampling and analysis for the presence of pesticides. Until this work is completed, no estimates can be made of the requirements for remedial actions in this lake.

6.2.8 Plugging of Deep Well - Planned Action

The injection well in Section 26 was briefly used in the early 1960's for high pressure injection of contaminated waste. Due to a series of small earthquakes in the area, disposal via this well was discontinued. A USGS instrument package, 4000 feet of copper tubing and 1950 feet of sucker rod have been lost down the well. Consequently, there is no access to the lower part of the well.

The Army plans to clear the well casing, run pipe analysis/cement bond logs through the well and plug the well. This method will maintain isolation between aquifers and create a stable hole condition. The well may then be completely abandoned with no possibility of problems arising in the future.

6.2.9 Inactive Secondary Source Monitoring - Planned Action

The National Contingency Plan (NCP) implementing CERCLA specifies guidelines for the cleanup of hazardous substances released from spills and inactive dump sites. In accordance with Subpart F (Hazardous Substances Response), each source area on RMA has been categorized according to its potential for migration. Primary sources have been addressed throughout this report in the development of control strategy components at the Arsenal. Inactive disposal sites with a potential to release pollutants to the surrounding environment (secondary sources) must be continually monitored to permit early detection of contaminant release that may pose an imminent and substantial danger to public health or welfare. If contaminant migration is detected, a reassessment must be made by the Army to determine what additional remedial action is necessary.

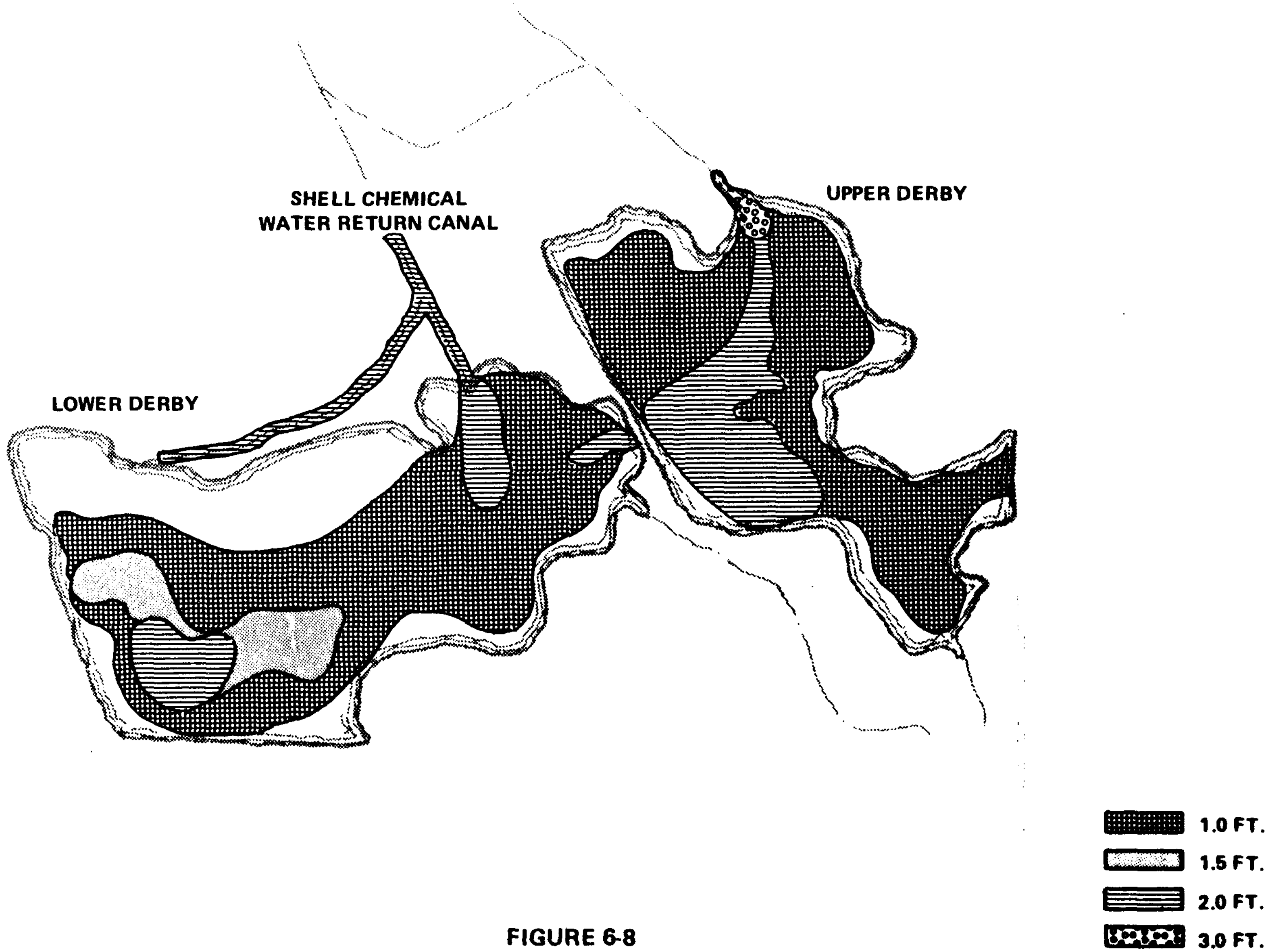


FIGURE 6-8
EXCAVATION DEPTH CONTOURS
IN LOWER LAKES

Current monitoring programs at RMA (Appendix C) have been structured for the primary source areas. These programs are being reviewed to assess whether modifications in sampling locations, frequency, or parameters are needed to comply with the intent of Subpart F of the NCP for the inactive sources. If changes are required, funding requests will be expeditiously submitted.

6.2.10 Basin F: On Site Landfill - Proposed Action

The closure scenario for Basin F includes removal of the hazardous material contents, and disposal in an on site RCRA designed landfill at an optimum location near the center of the installation (Section 36 is a prime candidate site). As previously discussed in Chapter 4, this scenario involves solidification of the liquid and overburden, removal of contaminated soil underlying the liner, disposal of the waste material in a landfill, and regrading and revegetation of the reconstructed basin area.

Implementation of this strategy component would take place in several stages. First the residual Basin F fluid/sludge would be pumped from the Basin to a processing plant where the solidification process additives would be mixed with the Basin F materials. The solidified product would be transported to the landfill, spread, and compacted. The final solidified liquid volume would be approximately 78,000 yd^3. Then the overburden would be removed (including the liner), transferred to the processing plant where 25% by volume of kiln dust would be added and mixed. The product would be transported to the landfill, spread and compacted. The final volume of the solidified overburden would be approximately 290,000 yd^3. Next, six (6) feet of soil under "Little F" and six (6) inches of soil under the rest of the Basin would be excavated, transported to the landfill, spread and compacted. The soil volume would be approximately 164,000 yd^3. Finally, the dike on the north end of the Basin (representing 70,000 to 100,000 yd^3) would be pushed into the Basin, contoured and revegetated. Approximately 93 acres of final cover would have to be revegetated. Ground water monitoring will be carried out for three (3) years to assure proper site closure.

The RCRA landfill capacity required for this Basin F strategy component is estimated at 530,000 yd^3. A single synthetic liner cell design will be employed to handle the Basin F wastes, Rail Classification Yard contaminated soils, and abandoned sewer line materials (see Figure 5-1 for typical cell design). Upon completion of disposal activities, the RCRA landfill cell(s) would be capped and monitored according to RCRA regulations.

6.2.11 Basin A "Neck": Containment/Treatment - Proposed Action

The containment system selected for the Basin A "Neck" control system will consist of a physical barrier with upstream dewatering and downstream recharge wells. The location of the barrier has been

chosen to intercept contaminated ground water migrating through the only alluvial exit out of Basin A. Recent borings and pumping tests have determined that the alluvium through the Basin A "Neck" area has a very low permeability and is connected with a saturated low permeability Denver sand. The proposed slurry wall would intercept the flow of contaminants in the alluvium and saturated Denver sand. The line of recharge wells will be located approximately 1000-1500 feet away from the slurry wall to facilitate recharge in the more receptive thicker alluvium. The treatment plant, containing both physical and chemical processes, would be located in the general vicinity of D Street for utility hookups. A central facility to treat both South Plants Area and A "Neck" ground water is a possibility that will be examined during system implementation (Section 6.3).

6.2.12 South Plants: Mound Dewatering - Proposed Action

To control further migration of contaminated ground water from the plants area, a dewatering well array will be placed within the South Plants Area to reduce the anomalous ground water mound. As stated before, this mound acts as a driving force of ground water away from contaminated zones beneath the manufacturing complex. Presently conceptualized, this system would include approximately 90 low capacity pumping wells placed within and at the north perimeter of the South Plants Area. Water level probes on each well would be set to reduce the ground water potentiometric surface to 5220 feet MSL; that of the natural surrounding water levels.

Preliminary pumping tests by Shell Chemical Company indicates that collective pumping of the dewatering wells in the South Plant Area might be expected to yield between 200 to 300 gpm over an 18 to 24 month period. After this period, steady state flow rates should be reduced to about 30 gpm. A smaller dewatering rate of approximately 100 gpm over a five (5) year period will be examined to minimize construction and operating requirements of the treatment plant.

6.2.13 South Plants Area: Surface Water Management - Proposed Action

The concept of surface water control is being developed to be compatable with the the previous control strategy components for Basin A and the South Plants Area which provide for containment of ground water contaminant migration. Surface water controls in the South Plants Area will divert clean water away from contaminated zones in Basin A and the South Plants Area to acceptable outfall points while at the same time isolating contaminated runoff within the plant complex. A proposed scheme includes construction of surface conduits to collect runoff and retention basins to hold surface flows that may be contaminated until the water can be sampled. Since the South Plants Area was originally constructed on a topographic high, the methodology for control must consider several

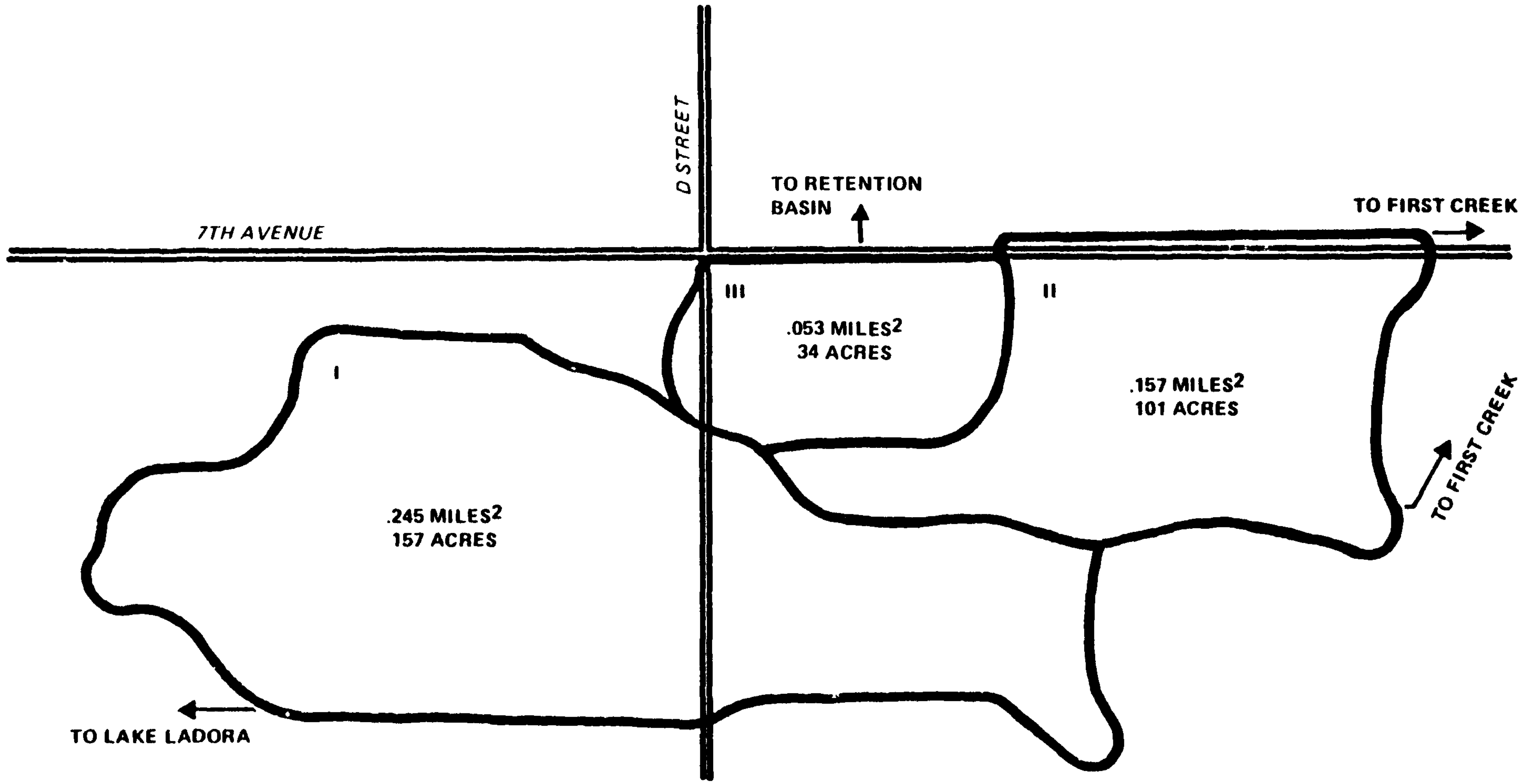


FIGURE 6-9
SOUTH PLANT
SURFACE WATER MANAGEMENT STRATEGY

drainage subbasins. Figure 6-9 depicts three such subbasins with appropriate notations as to area and receptor points. Subbasins I and II are believed to yield surface water of acceptable quality so that immediate release is possible. Subbasin III, however, has produced contaminated runoff of unacceptable quality. Lined conduits would transport this water to a retention facility for sampling if uncontaminated discharge to First Creek is envisioned. If contaminated, it would be routed to an existing treatment facility. All facilities would be designed to handle a 100 year, 24 hour peak flow storm event.

6.2.14 Rail Classification Yard: Soil Removal - Proposed Action

The source of DBCP being treated by the Irondale system is located in the Rail Classification Yard. This strategy component entails excavation of leachable contaminated soils within the yard and disposal in the on site RCRA landfill used for Basin F wastes. For the purposes of this study, it was necessary to assume the volume of soils requiring excavation is approximately 20,000 yd^3 since ongoing studies have yet to define the exact location and volume of the DBCP spill.

All surface structures will be temporarily removed during excavation operations. Once all contaminated material is removed, clean backfill will be installed. To complete the effort, surface structures will be replaced following any required decontamination. Ground water monitoring will be continued for three (3) years to assure cleanup was complete.

6.3 REQUIREMENTS FOR STRATEGY IMPLEMENTATION

Upon approval of the recommended strategy, numerous schedule, and technology requirements must be addressed. FY83 has been designated as the period in which all necessary design criteria on the "unit operations" level will be gathered to allow initiation of concept design in FY84 for long lead time strategy components. The following sections will expand on implementaton requirements such as construction phasing, and filling data gaps.

6.3.1 Schedule Phasing

Throughout many of the strategy components, an implied phasing of construction has been included. The primary example of this requirement would be those components including waste disposal. Prior to initiation of excavation operations at Basin F, Rail Classification Yard and the Sanitary Sewer Line, a central RCRA approved landfill must be permitted, in place and ready to receive wastes. Therefore, activities associated with getting the landfill programmed and approved as soon as possible should be completed to allow subsequent excavation operations to be implemented by FY88. Other schedule phasing, such as treatment facility construction at A "Neck" prior to physical barrier installation, are also present but can be best addressed within later construction design reviews.

6.3.2 Technical Data Gaps

Strategy components developed within this report have been conceptualized on the "technology" level. Prior to initiation of formal design at the "unit operations" level, numerous technical data gaps must be filled. The data developed must be continually assessed and updated to the design technical data package. A listing of the major gaps follow.

6.3.2.1 Basin F Closure

A study of the extent of contamination in Basin F was recently completed [10]. Laboratory studies on solidification of the liquid in Basin F are ongoing. A pilot solidification test program is required to provide verification of the laboratory results and operational criteria for a full scale solidification project. An enhanced evaporation program for the liquid in Basin F is in progress. As the liquid pool in Basin F decreases in area, investigation of the extent of contamination in the soil underlying the liner should be continued to provide information on the contamination volume existing beneath the liquid pool which could not be investigated in the previous study.

6.3.2.2 RCRA Landfill

A preliminary siting study for construction of a hazardous waste landfill at RMA is nearing completion. Additional studies are needed to secure detailed geotechnical, hydrological, and environmental data required for a permit application under RCRA. A final detailed design of the landfill must be developed. This information must be organized in a formal report for submission to the EPA, along with a permit application. The design information will provide input to an MCA program for final design and construction of the centralized disposal facility. In addition, supporting operational information must be developed and documented in formal report form as required by RCRA regulations (e.g., operating manuals, personnel training program plans, security plans, contingency plans, closure plans, etc.).

6.3.2.3 Basin A "Neck" Control

An investigative study is required to obtain additional hydrogeological data to finalize the location of the barrier, pump wells, and recharge wells, and to define the total number and size of the pump and recharge wells. Information obtained from this study will be evaluated and used as input to an MCA program for final design and construction.

6.3.2.4 South Plants Area Control

Additional hydrogeological data is needed to finalize the location of perimeter pump wells, and the pump wells inside the South Plants Area to be used for eliminating the mound, and to define the total number and size of the pump wells. Recharge capacity must be investigated at the A "Neck" area to assure water collected from the South Plants Area can be recharged at that location after treatment. Additional computer modeling may be warranted to verify operational conditions if a physical barrier is not placed between the Lower Lakes and the dewatering well array.

6.3.2.5 South Plants Area Surface Water Management

The concept of surface water control consists of collecting and diverting storm runoff from major sources in the Basin A and South Plants Areas. Several assumptions were made concerning the functional objective of the proposed strategy. These assumptions, particularly the statement that surface water from South Plants Area Subbasin III is contaminated, should be verified. Since data on surface water hydrology and runoff water quality are only preliminary, additional studies are needed to provide the data base for preparing criteria for construction of the conduits and detention basin(s).

6.3.2.6 Rail Classification Yard

Additional definition of the extent and distribution of contamination in the Rail Classification Yard is required. Data obtained in FY83 will be evaluated and used as input to final design and implementation of the excavation activity. As in the case of the sanitary sewer removal, debris and contaminated soil generated by the excavation must be interfaced with the operational schedule of the RCRA disposal facility.

6.3.2.7 Water Treatment Technology Development

Each strategy component has been conceptualized and costed assuming individual treatment facilities. Cost savings may result by the centralization of Basin A and South Plants Area treatment requirements into one single facility located in Section 35 near the origin of surface and ground water waste streams. Combination of similar process techniques into a flexible process train may achieve a lowering of technical risk and operations/maintenance costs. A schematic diagram of possible Basin A/South Plants Area central treatment facility is presented in Figure 6-10. This system could remove suspended and dissolved solids, volatile organics, adsorbable organics and oxidizable organics through the use of flow

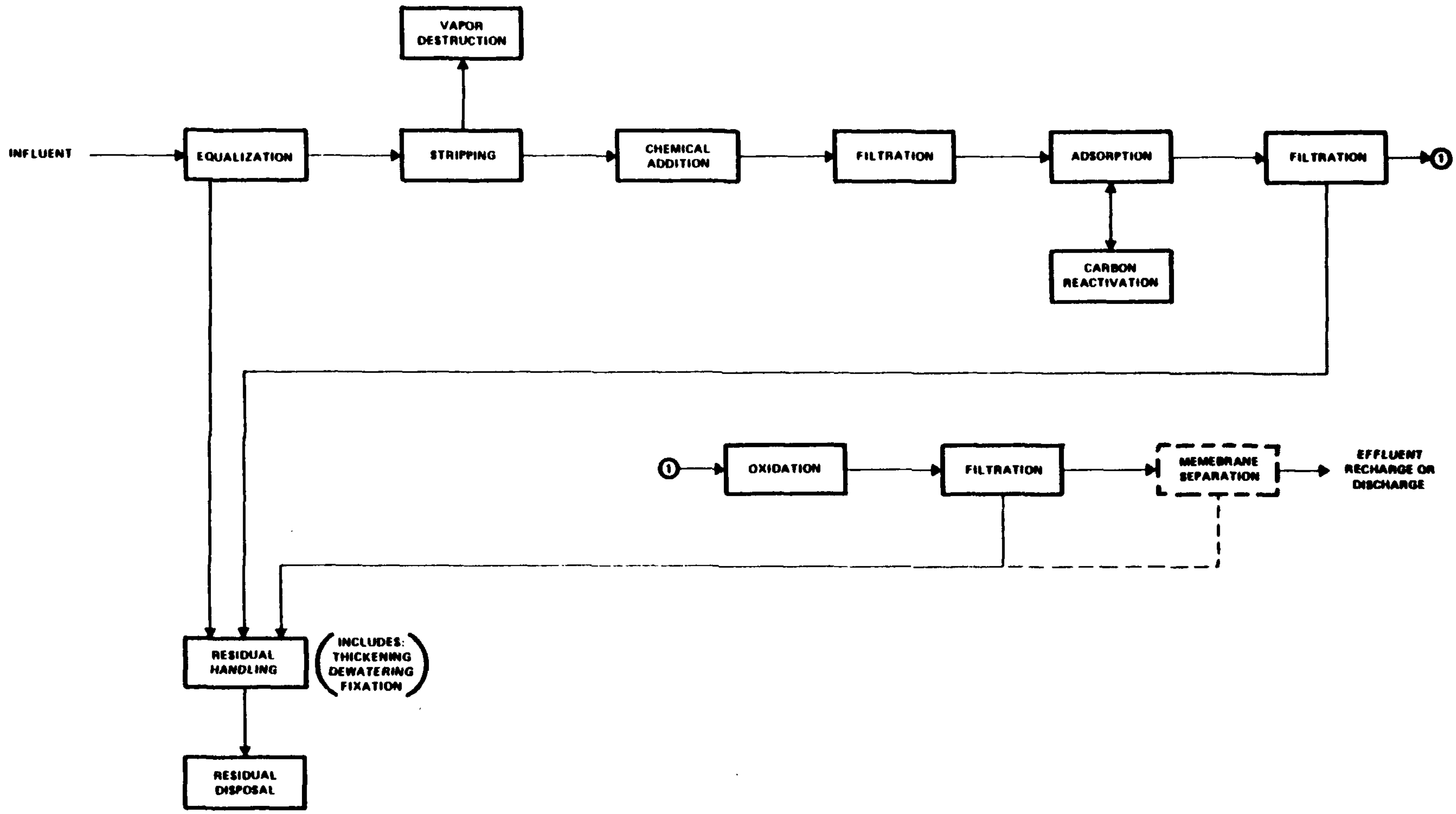


FIGURE 6-10
CONCEPT OF SOURCE CONTROL
TREATMENT FACILITY

equalization, air stripping, chemical addition, filtration, adsorption and oxidation. Addition of membrane separation may be required. A residual handling subsystem would have to be incorporated to allow economical final disposal of process waste streams. This system may also be appropriate, with modification, to treat domestic sewage from the South Plants and Headquarters Areas. Laboratory studies have been completed providing design and operational criteria for a pilot treatment system to be constructed in FY83. This pilot system should be operated on the various waste streams defined above to provide verification data on technical and cost feasibility for a centralized facility.

TABLE 6-2
CONTAMINATION CONTROL STRATEGY IMPLEMENTATION
COST SEQUENCING FOR RMA

FISCAL YEAR	CAPITAL $M (1982)	OPERATION/MAINTENANCE $M (1982)	REPLACEMENT $M (1982)	TOTAL $M (1982)
1983	0.94	0.582		1.52
1984	4.14	0.582		4.72
1985		1.452		1.45
1986	25.07	1.377		26.49
1987	11.56	1.270		12.86
1988		3.163		3.19
1989		2.770		2.80
1990		2.770	0.119	2.92
1991		2.440	0.054	2.52
1992		2.440		2.47
1993		2.584		2.61
1994		2.416	0.180	2.63
1995		2.416		2.45
1996		2.243		2.27
1997		2.243	0.360	2.63
1998		2.411		2.44
1999		2.243		2.27
2000		2.243	2.161	4.43
2001		2.243		2.27
2002		2.243		2.27
2003		2.411		2.44
2004		2.243		2.27
2005		2.243		2.27
2006		2.243		2.27
2007		1.926	5.76	7.72
2008		2.094		2.12
2009		1.926		1.96
2010		1.926		1.96
2011		1.926		1.96
2012		1.926		1.96
2013		2.094		2.12
2014		1.926		1.96
2015		1.926		1.96
2016		1.926		1.96
2017		1.926		1.96

6-2 12 20